SUPPLEMENT

TO THE

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CONTRIBUTIONS

TO

CANADIAN BIOLOGY

BEING STUDIES FROM THE

BIOLOGICAL STATIONS OF CANADA

1917--1918

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PREFACE.

BY PROFESSOR EDWARD E. PRINCE, *LL.D., M.A., D.Sc., F.R.S.C., Commissioner of Fisheries for Canada, Chairman of the Biological Board, Life Member of the British Science Guild, Vice-President of the International Fisheries Congress, Washington, D.C., 1907, Member of International Relations Committee, American Fisheries Society, 1917, Chairman of Food Refrigeration Committee, Canadian Research Council, Ottawa, etc.*

The staff of scientists at the Dominion Biological stations at St. Andrews, New Brunswick, and Departure Bay, Nanaimo, British Columbia, have continued their laborious investigations into fishery problems and the marine and fresh-water resources of Canada with unabated energy and zeal. The results, or rather portions of them, are contained in the sixteen reports now published.

The subjects cover a wide range, and in many cases deal with vexed questions vitally affecting our fishing industries.

It is simple justice to say that many of the researches now presented were carried on with much sacrifice on the part of the scientists engaging in them, and without any remuneration at all, or with meagre acknowledgment in the form of an inadequate honorarium.

As chairman of the Biological Board of Canada, and for twenty-five years the chief adviser and scientific fishery authority of the Government of Canada, I desire to testify to the zeal, skill, and laborious devotion of the qualified and trained specialists who completed the investigations contained in the pages of this volume of " Contributions to Canadian Biology."

The biological stations, in their laboratories, libraries, instruments, stores of chemicals, glassware, and fishing gear, provide facilities of no ordinary kind for workers trained in the science schools of our Canadian universities, but these facilities, by a rigid rule of the Biological Board, are available only to advanced students, professors, or members of university staffs, and qualified, therefore, to undertake original research and discovery. Unlike the Biological Stations in many other countries, no courses of instruction or elementary lectures are given, and no attempt at popularizing science made. To add to the knowledge, so urgently needed by our fisheries, to increase accurate information on which fishery legislation should alone be based, have been the main objects aimed at; but it is possible that some scheme of fishery education and the dissemination of popular information, regarding fishes and aquatic resources generally, may be added to the future plans of the Biological Board.

The authors of the papers now published represent the following Canadian Universities: Toronto, Queens (Kingston, Ont.), McGill, Western University (London, Ont.), Laval, Manitoba, Dalhousie (Halifax, N.S.), Acadia (Wolfville, N.S.), and New Brunswick (Fredericton); and other scientists from the United States and from Canada have also contributed.

The stations have now the advantage of resident scientific curators, viz: Dr. A. G. Huntsman at St. Andrews, N.B., and Dr. C. McLean Fraser, at Departure Bay, B.C., and a new impetus to successful work has been given by the labours of these gifted and distinguished Canadian biologists.

As in preceding volumes of the " Contributions," I have prepared brief summaries of the reports which follow, for purposes of easy reference.

I. SEA-LION QUESTION IN BRITISH COLUMBIA, A REPORT BY SPECIAL COMMISSIONERS—(W. Hamar Greenwood, F. C. Newcombe, and C. McLean Fraser).

The report, with thirty-six half-tone illustrations, refers, in its opening pages, to the steps taken in the United States, and the controversies arising out of the late Professor Dyche's studies on the Californian sea-lion (*Zalophus*), which devours squid, and to the conclusions of the California Commission of 1901, which decided that Steller's sea-lion (*Eumetopias*) is largely a fish-eater. Dr. Newcombe and his son published, in 1914, a report in which it is stated that, at River's inlet, damage to nets (estimated at $1,600 in 1915), and mutilation of salmon, were the charges laid against the sea-lion; while at Barkeley sound, it was claimed they drove away schools of fish, and devoured enormous numbers of herring and halibut. It is claimed that in 1913, damage to the extent of over $3,000 was done to one British Columbia Packer's Association (Wadham's) cannery.

After a cruise to various localities on D.G.S. *Malaspina*, securing of evidence from practical men at different points, and after much correspondence and transmission of questionnaires, it was found that the sea-lion, in the opinion of most of the witnesses devoured food fishes, salmon and halibut being most frequently noticed, sockeye and coho salmon, as well as herring and shore fishes, were mentioned, but no dog- or hump-back-salmon. In one instance, dogfish and birds are mentioned as being devoured. The parties who gave information were unanimous in their view that sea-lions are food-fish destroyers, and they were equally unanimous in favour of the killing off of these animals, and of a government bounty to encourage total extermination. One prominent witness however, said: "Don't kill them off; but strike terror into them".

The bands of sea-lions appear in Barkley sound in November, and were reported to the commission as being numerous in various inlets early in December. Thirteen were killed at Bird Rocks, a principal resort and hauling ground, and on examining the food, it was found that herrings in a perfect, undamaged condition were found in all of them, as much as two gallons of these fish being mingled with other partially-digested food. Remains of flat-fish, squid, etc., showed the sea-lion to be a bottom feeder, and the finding of the vertebræ of a dogfish (*Squalus*) suggests that if sea-lions were exterminated, the dogfish might be a still greater pest than they are at present. In 1913, 11,000 sea-lions was estimated as the total number on the B.C. resorts, but there were probably considerably more.

In 1915-16, a government bounty was paid on 4,000 sea-lions killed, though 8,000 (6,000 being pups) was nearer the total number, and some rookeries were entirely destroyed.

Sea-lions can be utilized in various ways. The flesh yields oil, and guano; and the skin makes excellent leather for gloves, moccasins, and boots. The British Columbia Glove Company, and other firms, would pay 5 cents per pound for hides, if 5,000 could be supplied with certainty. It is said that sea-lions will bring about $1,000 profit to each hunter for one month's work in California. The hides, after heavy salting, are usually tanned in San Francisco. The hide may weigh 150 pounds, and the whole animal from 1,500 to 3,000 pounds.

As to the effect of the Dominion Government bounty ($2 for each muzzle), it did not prove an unqualified success, as the hunters killed sea-lions on rookeries too far distant to affect the fishing localities, such as River's inlet, etc. The appropriation was soon exhausted, and no bounty was obtainable for those men who killed sea-lions nearer at hand, as in Barkley sound.

Many scientists are not convinced of the alleged serious damage to valuable fish by sea-lions, and further study of their life-history and habits is urgent. In some localities the chief run of salmon is just after the pupping season, when the sea-lion

is not feeding, according to zoologists. In the opinion of the commission, sea-lions should be reduced in number, or driven away from localities where damage can be done; but on many rookeries there is no necessity for extermination, especially as valuable products (oil, leather, and fertilizer) might be obtained by creating a sea-lion industry. In such case, a wise method would be to adopt official control of sea-lion destruction conjointly with conservation, and a certain number only to be killed each year.

The second part of the report describes, in detail, the various rookeries, and estimates the total number of sea-lions upon them.

II. LOBSTER INVESTIGATIONS, LONG BEACH POND, N.S.—

(PROF. A. P. KNIGHT).

The author, in his report on the lobster investigations at the Government pond in Nova Scotia, during the season of 1915, commences by distinguishing between the nature of the sea lagoon, or pond of 5 acres, and the pond of three-quarters of an acre enclosed by cement walls. In 1914 the latter leaked extensively, but the department repaired the leak. Later, leakage again occurred, but was repaired, and on Dr. Knight's arrival on June 26, 1915, the water was 5 feet 8 inches deep, at low water. Next month it leaked again, and the rearing boxes ($10 \times 10 \times 2\frac{1}{2}$) rested on the mud, and by August 7, two boxes were immersed 5 inches in the mud. At the United States lobster station, at Wickford, R.I., where rearing was first carried out, there is always 12 feet of water underneath the boxes at low tide, excepting at one corner, where there is $5\frac{1}{2}$ feet.

Early in July a vegetable parasite threatened the young larvæ, there being 40,000 hatched in the four boxes by July 14, but the parasite was *Licmophora Lyngbyei* (in 1915), instead of the species in 1914, *Synedra investiens*. To avert loss of fry, two boxes were removed into the water of the bay, but 20,000 fry were retained in two boxes were removed into the water of the bay, but 20,000 fry were retained in two boxes in the pond. Nearly all the latter were lost, only twenty-one surviving, in the second stage, on July 30. On August 2 a further trial with over 20,000 fry had a similar disappointing result; only 146 fry, in the second stage, survived until August 17. When canvas shades were used, to shut off the sunlight, the first stage lasted nine days instead of thirteen (when unshaded), and the water was 1 degree warmer. The greater success at Wickford, where 40 per cent of the lobster fry were reared, may be due to: (1) greater depth of water under the boxes; (2) comparative absence of mud and diatoms; (3) a higher temperature, 68° to 75° instead of 58·09° to 58·9°, and these conditions are of paramount importance. If the sea-water were heated to 68° or 70°, it would require 250 pounds of coal every twenty-four hours to effect this, as 2 cubic feet of water per minute passes through each rearing box.

The adult lobsters, early in 1915, were found to be covered with growths of sea-weed, and from that cause, and the muddy water, out of 167 left in the pond, 33 appeared to have perished; but of 312 not more than 38 died from the pound-conditions in 1915, the reduced mortality being due to care in collecting, feeding, and distributing them, and in shorter detention.

The author's notes on the egg-laying of lobsters are very interesting. Half of the females extruded only a few hundred eggs, instead of many thousands, and at least 80 per cent of these eggs were unfertilized. Unfertilized eggs soon drop off, and it is easy to see why fishermen find so many she-lobsters not carrying eggs, and

the eggs, indeed, are often eaten by the female if unfertilized. In one case the eggs did not adhere at all, but floated soft and jelly-like on the water.

Moulting took place, though in some places the creatures did not survive, as they were weak, and the materials for a new shell were lacking. Some lobsters were blind, but moulting restored the sight; sea-weed growths often penetrated into the eyes, and underlying tissues, which were thus destroyed.

Of 47 females impounded in midsummer, 1914, 30 had extruded eggs by the end of September, and on April 8, 1915, these 30 lobsters were all found bearing fertilized eggs, showing that 64 per cent carried fertilized eggs from June, 1914, to June, 1915, most of the eggs being extruded, however, in August. By the 7th of July, 12 had hatched and got rid of the eggs, 12 bore eggs nearly in the hatching stage, 2 had newly extruded eggs. On the 29th of July, 7 of the 12 bore new eggs, and as they had already produced new eggs, there were thus 9 which proved that annual spawning was true of these lobsters at any rate.

The conclusion reached is that some lobsters are annual, others biennial, spawners, and others do not spawn even biennially.

Apart from the primary object of the Government pond, viz., saving berried lobsters in the open fishing season and liberating them in the close season, a pond of this nature may be used to secure intercourse between the two sexes, and increase the production of fertile eggs. The author justly regards his results as very important, when the production of fertile eggs resulted on placing 15 males in the pond with 47 females, in 1914-15.

A few more Government ponds might be built along the Atlantic coast, to extend the tests made at Long Beach, and promote beneficial results, viz., the increase of egg-laying. The paucity of berried lobsters in the open sea, as compared with the far greater percentage in the enclosure is obviously explained by the close intercourse secured by impounding both sexes, as at Long Beach.

III. THE PEARLY FRESH-WATER MUSSELS OF ONTARIO

(Mr. John D. Detweiler, M.A.)

The pearl-button industry depends upon material provided by pearly shells and mussels, which occur in many Canadian rivers and lakes; hence, the economic importance of the research reported upon by the author. He describes his studies at the Fairport station, Iowa, where these pearly mussels have received special attention. Young mussels (glochidia) become attached to the gills and fins of fishes, for a couple of weeks, before entering on an independent existence. These infant mussels, 1,000 to 2,000 in number, may attach themselves as parasites on a single fish, and of the nine or ten species of common pearly mussels, each species has its own special host or particular fish.

The mussel fishery, for button purposes, tends to reduce the supply of these shellfish very seriously; hence artificial propagation and increase are desirable, as in the United States, where such mussel-culture has been very successful, and over 330,000,000 glochidia were used to infect about 430,000 fish in one season. The supply of common mussels was studied by the author in a number of Ontario waters, and details are given of the Grand river, river Aux Sables, Point Edward bay, and Nottawasaga. and many others. *Lampsilis luteola* and *Quadrula plicata*, and other species, have good commercial qualities; but many species are too thin to be of use. The shells are fished by wire scoops, with long handles, worked from scows, which are towed by a

gasolene launch. After being boiled, the meat is removed from the shells and many pearls and slugs are found, some of value. The increasing violence of floods, in the rivers studied, must have been injurious to mussel beds, and the regulation of the flow of water is essential. Vegetable detritus on river beds, and small diatoms, etc., appear to form the food of these mussels, and favourable conditions for such food should be maintained.

The prohibitive steps suggested include annual close times, size limit, restriction of methods, closed reserves, and a license system, as well as the adoption extensively of mussel culture. No less important are the stocking of waters by transferring mussels, and the rearing of the best species by mussel inoculation, etc.

IV. THE SHIP-WORM (TEREDO) ON THE ATLANTIC COAST OF CANADA—(Dr. E. M. Kindle).

The destructive character of the ship-worm (*Teredo*) has long been known; but its rapidity in boring timbers is not so well known, and the author instances a beech log, at the west side of the entrance of Charlottetown harbour, Prince Edward Island, thoroughly honeycomed recently during the short period of eleven months. A half-tone illustration shows this log, and demonstrates how much more rapidly *Teredo* works than the boring shrimp (*Limnoria*) which destroys soft timber at the rate of half inch per year. Timber cut from February to May best resists *Teredo's* attacks, and in the cold winter season it is inactive. The tunnels bored, lime-lined, do not intersect, and it is rare for *Teredo* to pass from one timber to another. At the water-line and in the false keel of vessels are the main places of attack. *Teredo* spawns from April to August in Iceland, but in Canada it is probably about July. Mud seems to deter the boring operations; but, where the bottom is sandy, injury is more prevalent. Thorough application of creosote (14 to 16 pounds impregnation to the cubic foot) is effective; but at Christiania, piles were attacked when 10 pounds to the square foot were applied. The ship-worm survives for 10 days, but not beyond two weeks when removed from the water and kept in a cool place. Freezing (temperature 6°C.) does not kill them; but they die in two hours in fresh water. A large ship-worm reaches a length of about a foot (30 cm). The prevailing European species (*T. norvegica*) ranges from the Mediterranean to southwest Norway, but within Arctic limits, Prof. G. O. Sars records it only in piles in west Finmark. *Teredo navalis* the species in Canada, shows discontinuous distribution on the Atlantic shores of North America (see Dr. Kindle's sketch map). Rare or absent in the Bay of Fundy, and scarce north-east of Halifax, it occurs abundantly all round Cape Breton and the southern shore of the gulf of St. Lawrence, including the shores of Prince Edward Island. According to Dr. Murphy it is especially destructive about Sydney harbour.

The presence or absence of the ship-worm may be due to temperature, salinity, and amount of fresh water, and probably turbidity or silt in the water. It is often associated with the boring shrimp in its range, and may overlap, but one becomes less plentiful, it may be said, as we advance into the territory of the other. A number of molluscs associated with *Teredo* in their distribution occur in warm areas, and show similar isolation and discontinuity. Off southeast Nova Scotia the 20-fathom line approaches within half a mile of the coast, and everywhere a narrow zone of shoal water inside the 100-fathom line renders it colder than the Northumberland straits, where 20 to 10 fathoms or less prevails over a large extent. A zone of shallow water, if close to and unprotected from deep water, is as effective a faunal barrier as a land

barrier, a point worthy of more attention from palæontologists. The isolation of *Teredo,* and the warm-water mollusks referred to, is recent, and the occurrence of oyster shells 40 miles southwest of Halifax, and at Cole harbour; in Chaleur bay and north, as far as Montreal, indicates that a milder climate once extended from southern New England to the waters of the St. Lawrence.

V. REARING B.C. SOCKEYE SALMON IN FRESH-WATER.

(Dr. C. McLean Fraser).

After references to well-known attempts to rear Atlantic salmon and sea-trout, especially in Scotland, without permitting them access to the sea, and pointing out that slower growth and smaller sizes were apparent when retained in fresh water, the author states that in the fall of 1912, sockeye from Harrison Lake hatchery were placed in the small rearing ponds, New Westminster, B. C. These had been hatched in the spring of 1913, and in 1915 males were found to be ripe, and after yielding milt they recovered condition. But the females did not become ripe until their fourth year (1916), when they were from 9 to 11 inches long, and their eggs were rather small, but they were artificially fertilized, and an attempt to hatch them made. Study of the scales showed that these pond-reared fish indicated a growth which can be compared to that of the river sockeye to the end of the second year, but the third year's growth showed a decrease, and the fourth year's a still further decrease in the rate. The average growth in inches each year shown by the author is as follows:—

	1st year.	2nd year.	3rd year.	4th year.	5th year.
Sockeye reared in fresh-water...	2·7	2·3	2·3	1·6	...
Sockeye from Fraser river (fifth year)	2·9	8·6	7·7	3·1	...
Sockeye two years in fresh-water.	2·6	3·2	8·2	6·1	2·4

Most of the Fraser river fish remained one year only in fresh-water after hatching, and the author gives figures for these. There is no question that the sockeye mostly die soon after spawning, but the pond-reared fish recovered after spawning, and seemed none the worse. This environment renders the fish apparently more like a fresh-water species, and indicates, in the author's opinion, a close relation to the Genus *Salmo.*

VI. AGE AND GROWTH OF POLLOCK—(Prof. J. W. Mavor).

The pollock has in recent years so greatly increased in commercial importance that information upon its age and growth is valuable. The author found that young pollocks' scales show no winter rings, indicating that during their first year they live in shallow water. They occur in 2 to 20 fathoms, and in about a dozen hauls of the drag seine interesting catches of these young pollock were made; but when about 11 cm. probably move into deeper water, so that the seine does not secure them. Two length measurements were adopted in these studies, namely, the standard length, the

tip of the snout to end of backbone, and total length measurement, from snout to end of outspread tail. As in the case of the herring, one single year in the pollock will yield so abundantly that it predominates for several successive years, and the author now confirms the conclusion of Mr. Douglas Macallum in 1914, that the fish of 1909 were the most abundant year-class in 1914, 1915, and 1916. The material obtained for the studies of second-year fish showed that they range from 29 cm. to 45 cm. and were probably large for their age. Fish in the third year, with two winter rings showing in the scales, were 36·4 cm. standard length and so on up to the seventh year, when they measured 72 cm. Macallum studied 1,250 pollock in 1914-15, and Dr. Mavor, in the course of his work, examined and obtained material from 2,387 fish.

Detailed tables are given to establish the author's results.

VII. HYDROGRAPHICAL OBSERVATIONS, BAY OF FUNDY—(Mr. E. H. Craigie, B.A.; Mr. W. H. Chase, B.A.)

The authors give the results of two cruises in the Bay of Fundy, 1915, to confirm and extend the hydrographical observations already published. Fifteen stations were established, and third and fourth cross-sections, and one longitudinal section of the bay completed. It is noted that:—

(1) A higher temperature prevails in the deeper water layer; indeed, a cold tongue of water occupies the middle of the bay. In one instance, at Station I, a peculiar rise, in a depth of 40 to 70 fathoms, also a rise at Station IX in 20 fathoms; and (in 1914) at Station II (60 fathoms), were discovered, probably evidencing deep currents.

(2) The upper regions of the bay show a very constant temperature from 5 fathoms to the bottom. The first phenomenon is due, probably, to vertical rising of the water, owing to the great tides; and the second, to the more widespread and complete tidal mixing of water at the head of the bay. The air was in no case less than 2·2 degrees warmer than the surface water, and often more; but it is noted that H.M.S. *Challenger*, in a few cases only, found the water temperature higher than the air, in the adjacent Nova Scotia regions. The *Challenger* and *Helland-Hansen* results are not, therefore, confirmed on the whole. The temperature of the water tends to be higher on the Nova Scotia side than on the New Brunswick side, and the bottom temperature of the Annapolis basin is much lower, in many cases, than that of Digby Gut, or the inflowing river-water. The detailed results are given in three tables: (1) showing temperature records, Bay of Fundy, 1915; (2) showing temperature records, Annapolis basin and St. Mary bay; (3) specific gravity, etc., St. Mary bay.

VIII. AFFECTED SALMON, MIRAMICHI HATCHERY, NEW BRUNSWICK—(Principal F. C. Harrison).

In the fall of 1915, disease appeared among the live parent salmon in the South Esk hatchery pond. Of 2,400 fish nearly one-quarter showed fungus, scales eaten off, eyes blinded, and many salmon moribound. No unhealthy conditions appeared in the pond or inflowing water supply, according to the information furnished. Exact

bacteriological studies were arranged, and cultures made of portions of the flesh, liver, kidney, swim-bladder, milt, and heart's blood. Diseased portions of the skin were studied in microscopic sections, and in teased fragments. The latter afforded the best results. The first stage of the disease was noticed in fish conveyed in pontoons from the fishermen's nets. The fungus was *Saprolegnia,* but it remained to be seen if it were a primary or secondary cause of the trouble, and no live salmon could be inoculated; but an experiment was made with gold-fish. In all the organs, apparently healthy, of the salmon examined, bacteria were found in great numbers, but of a few species only. Very exact technical methods were used, and ten different forms of bacilli were distinguished in the cultures made, in about a dozen media, with results tabulated by the author on page 165.

The important *Bacillus salmonis pestis,* a short thick bacillus, with rounded ends, varying in length, and occurring singly and in pairs, end to end was not found. It is actively mobile, non-sporebearing, and survives for a week, and indeed grows profusely in the temperature of ice-and-salt mixture, but is killed at 98·6° F., and is apparently a strict aerobe ,pathogenic to fish, but not to frogs, mice, etc.

It gains access through wounds, or ulceration in the fish's skin. It grows well in sea-water, and can be transmitted from dead, diseased fish, to live fish in the same water. Attempts failed to inoculate live gold-fish with the various bacilli described.

The author's conclusion is that numerous bacteria associated with the fungus, may be the cause of the disease.

IX. AFFECTED MIRAMICHI SALMON, NEW BRUNSWICK -

(BY. DR. A. G. HUNTSMAN).

The author, after noting that an epidemic of disease such as this had not been noticed in the previous year, and that the temperature was lower than in 1914, and the water temperature in the salmon hatchery pond was never higher than 65° F. after September 11 the author concludes that temperature is not a factor. The lower temperature in October doubtless restrained the spread of the disease, as no new diseased fish appeared. The fish were less crowded, there being 328 fewer impounded than in 1914. The salmon parasite (*Lepeophtheirus*) occurred in a considerable portion of the fish trapped by the fishermen, and as it injures the skin it must determine the location of the fungus (*Saprolegnia ferax*). The internal organs of the diseased salmon showed no lesions, but the bacteriological phase of the epidemic is treated in Dr. F. C. Harrison's report. Removal and destruction of all diseased and dead salmon alone can help to lessen the trouble, and steps are necessary to secure improvement in the renewal of the water supplying the pond. The most suitable temperature also should be maintained. The eggs from diseased fish were naturally of lowered vitality, and great losses, 40 to 60 per cent, resulted. *Saprolegnia* may attack eggs only of low vitality. Bacteria possibly cause the disease, but may not affect the eggs, and fry could not in this way have the disease transmitted; but it may be carried in the water used for shipping eggs and fry.

X. THE SMOKING OF HADDOCKS FOR CANADIAN MARKETS—(Miss Olive G. Patterson.)

Salt and smoked haddock are too often prepared, it is pointed out, from fish inferior in quality or even tainted, whereas the best "finnans" can only be made from fish in the freshest condition, kept cold, and cured by strict methods. Finnan haddies in Canada are often inferior because: (1) no vertebral cut is made; (2) smoke is not sufficiently dense; (3) the fish are left from one to three days, in order to drain the blood, etc., away, whereas one hour on ice would be sufficient.

Various conditions were tested, namely, method of splitting, time in brine and smoke, quality of brine and smoke. The studies included seven separate experiments:—

(1) Perfectly fresh fish cured by usual New Brunswick methods.
(2) Salt constant, but smoke varied.
(3) Smoke constant, but brine varied.
(4) Small fish, under variations of both conditions.
(5) Preservative value and palatability of salt content.
(6) Hake experiment.
(7) Proof that dorsal incision is most desirable after the usual splitting.

Fish up to four pounds require one hour in the brine, but thirty minutes suffices to preserve excellent flavour, and smoking (beech, or old wood sawdust) for ten hours is sufficient, but fifteen to eighteen hours dries more thoroughly, for preserving. Adjacent home markets and more distant markets require appropriate variation in details.

XI. OBSERVATIONS OF HADDOCKS, ETC.—

(Prof. F. C. Harrison).

Rigid bacteriological methods were followed in the study of material obtained from haddocks, caught one or two miles from St. Andrew's station; and some other material, fresh and cured, from the market.

An examination of the intestinal content of twelve haddocks was made, and microscopically numerous small bacilli, of at least ten species, could be determined, but no cocci or spirilla were observed. The most common bacillus, a liquefying form, seemed to be related closely to *B. vulgaris*. It is especially interesting, because it was found in the flesh, as well as on the surface, of the finnan haddies, which were experimented with at the station, and also on some spoiled haddock from a fish dealer. Fragments of the flesh of cured haddock were placed in inoculation flasks, and plate cultures secured. Four of the organisms then discovered were similar to those from the intestinal content. The researches show that salting and smoking fish does not kill the organisms on fresh fish, after they are gutted; but it is undeniable that there is too much carelessness in handling fish commercially. Exposure to warm air and sunlight, before gutting and salting, increases the bacteria.

XII. BACTERIOLOGY OF SWELLED CANNED SARDINES.—(Mr. WILFRID SADLER, M.Sc., B.S.A.)

After referring to the presence of micro-organisms in various foods, including mussels, clams, canned salmon, etc., the author refers to the canned method in the New Brunswick and Maine sardine canneries, which he visited. The filled and finished cans are sterilized in boiling water for 1½ to 2 hours. Scrupulous care is exercised in the final packing processes, and questionable cans are discarded or re-processed.

Two main classes of bacteria were isolated; (1) gas-producers of eight types; (2) non-gas-producers.

No organisms were found in the cotton-seed oil used, but in the sea-water, herring intestines, etc., several strains of bacteria were discovered, but none producing gas in carbo-hydrates. After a description of the seventeen or more media used, and the methods adopted, Mr. Sadler describes the features of the swelled cans, the bulged convex appearance, the escape and forcing out of oil or sauce between the soldered edges, and a rattling sound when shaken. Gas is expelled on opening the can, and the odour may be normal, or offensive. In the former case, doubtless spices and other ingredients hide the odour of putrefaction. The contents may be soft, mingled with the oil and maceated, in contrast to the firm non-macerated white appearance of the normal contents.

The elaborate cultures and tests in the laboratory are detailed by the author, and summarized on pages 208 and 209. An experiment was made with normal cans from the Chamcook factory, and the organisms, numbers 35, 37, and 64 were used for inoculation. These organisms were, respectively: (1) a large coccus, not-motile, rod-like, short, and thick; (2) rod-like, and three times as long as broad; (3) some ranging from the coccus to short thick rods. In each case, typically swelled cans resulted.

The source of the harmful micro-organisms remains to be discovered, and the stage at which infection occurs; also effective prevention and the results of the effects, by experimental inoculation, on laboratory animals.

XIII. BACTERIAL DESTRUCTION OF COPEPODS.—(Mr. WILFRID SADLER, M.Sc., etc.)

In some marine plankton, studied at the Atlantic station, in 1916, a number of copepods, or small crustaceans, were observed by Professor Willey to be apparently in process of destruction by bacteria. It was suggested to the author, by Dr. Willey, that a study might be made of them. The copepods occur in the central cavity of the first feelers or antennæ. By the usual bacteriological methods, and by seven fish concoctions, specially prepared, three different types of bacteria were isolated, fourteen media being used in the investigation. The first type were short, rod-like, non-motile organisms, non-spore-bearing, and without capsule; the second was of the same length, but twice as broad, not much longer than bread, and similarly non-spore-bearing, and apparently capsuleless, and lastly a third type, coccus, either in pairs or occurring in masses in the form of Streptococci, non-spore bearing, and with capsule faintly apparent. The first is probably *B. neapolitanus,* a sub-type of *B. coli*; the second, rapidly motile to and fro, or on an axis, and a typical form of Para-Gærtner group; and the third non-motile, though rotatory, and showing violent agitation, a variety of liquefying *Streptococcus gracilis*, namely *Micrococcus zymogenes,* and the last-named culture probably causes the destruction of the copepods, and if this destruction be extensive, its effective upon the minute food of young fishes, and a variety of other important creatures in the sea, may be serious. No inoculations of healthy living copepods was possible in 1916.

XIV. CHECK-LIST OF MARINE INVERTEBRATES.—(Dr. E. M. Kindle and E. J. Whittaker, M.A.)

The authors, in their list of over 1,000 invertebrates, occurring along the Atlantic shores of Canada, set forth the bathymetric range from between tide marks to a depth of 100 fathoms—five graduations, namely, 100, 100-50, 50-15, and 15-1, and inshore less than 1 fathom; also the minimum and maximum depths.

They embody published faunal results from 1901, the date of Dr. Whiteave's valuable and remarkable catalogue, published by the Geological Survey. To make the contribution more complete a bibliography of fifty papers and memoirs follows the check list, to which is added an alphabetical index, including synonyms.

XV. HYDROGRAPHY IN PASSAMAQUODDY BAY AND VICINITY.—(Rev. Professor Alexander Vachon.)

Professor Vachon made a series of observations during a number of cruises in the *Prince* in the summer of 1915, and gives a summary with tables of his researches into the temperature, salinity, and density of the sea-water at ten successive stations in July and August, at different hours, and at different stages of the tide. These constitute the potent factors which affect the assemblages of marine organisms forming the benthos, the nekton, and the plankton, in the ocean. The investigations of the author, involving lengthy laboratory studies, are difficult to summarize, as the paper itself is very much condensed.

XVI. THE HYDROIDS OF EASTERN CANADA.—Dr. C. McLean Fraser.)

The author is able in this paper to extend substantially the list which he published in 1913 (a list of fifty Nova Scotia species) and now determines 112 species, sixteen for the first time in the area referred to, and one species which is regarded as new to science. The distribution is tabulated, and an interesting summary of the distribution of the Gymnoblastea, the Campanularidæ, and five other orders. A systematic list, with distribution and synonyms, is given, and the author discusses the principles of the classification of the hydroids, and combats Levinson's view that the character of the individual (zooid), not the colony (zoarium), should determine the classification, and the doubtful value of the operculum (urged by Levinson) as the sole basis for dividing the Family Sertularidæ into genera is maintained, because it is so easily injured, and thus readily altered.

I

Part I.

PRELIMINARY REPORT OF THE COMMISSION ON THE SEA-LION QUESTION, 1915.

Dr. Charles F. Newcombe, Victoria, B.C., Chairman;
Wm. Hamar Greenwood, Vancouver, B.C., Secretary; and
Dr. C. McLean Fraser, Curator of the Government Biological Station, Nanaimo, B.C.

Introduction.

In May, 1915, the Biological Board of Canada appointed an honorary commission to make an inquiry as to the effect of the bounty of two dollars per head which had been offered by the Dominion Government to aid in the reduction of the number of sea-lions in the province of British Columbia, and which applied during the year 1915 only.

The commission, after some changes, finally consisted of Dr. C. F. Newcombe, of Victoria, chairman; W. Hamar Greenwood, B.A., of Vancouver, secretary; and Dr. C. McLean Fraser, of the Biological Station, Nanaimo.

Early in August, Prof. A. B. Macallum, of the University of Toronto, Secretary of the Biological Board of Canada, visited the west coast and met two of the commissioners at Vancouver. Authority was then given for an early commencement of the investigation, but it was left to the commissioners themselves to draw up a plan of operation which would best fulfil the purposes of the proposed inquiry. The commissioners at once decided that there should be a division of the work of the commission, Mr. Greenwood undertaking to collect all information possible by correspondence and personal interviews, the other two members more especially devoting their time to field and laboratory work, with the view of gaining more knowledge as to the life-history of the sea-lion.

In order to facilitate the statistical section, a schedule of questions was drawn up and forwarded to officials of all the fishing plants of the province, and, for the field party, application was made through the Biological Board for the use of one of the vessels belonging to the Department of Naval Service. These matters are referred to later in the report.

2. Action elsewhere on the sea-lion question.

The sea-lion question is by no means a new one. As long ago as 1898 it was very much to the fore in California. In 1899 the State Commission authorized the killing of numbers of the animals, giving the reason for so doing in the sixteenth biennial report of the State Board of Fish Commissioners of the state of California for the years 1899-1900, pp. 26-40. In this report is included, as well, much correspondence on the subject.

At the outset, in April, 1899, the commissioners called a meeting of all persons interested to consider the evidence that might be offered regarding the damage done by sea-lions. The reason given in the report for calling this meeting is as follows: "For many years the fishery interests have strenuously complained of the damage done by sea-lions in the bays and rivers of the state. This commission has had the subject under consideration for many years. During the fall of 1898 and the spring of 1899 the salmon fishermen made repeated calls upon us for relief in this behalf, claiming that the sea-lions were appearing in the bays and lower rivers in increasing numbers, and that they follow the salmon from the ocean for more than 100 miles

inland. The managers of the canneries and the buyers for the San Francisco markets joined in these requests. Our patrol force corroborated the statements and alleged that the territory covered by them swarmed with these animals. Formerly the sea-lions were hunted for commercial purposes, but their hides and oil no longer find a profitable market, and the industry has failed, in consequence of which they have greatly increased in number."

Fishermen, market men, and cannery men were unanimous in asking for a reduction in number on account of the destruction by them of salmon and other food fishes. So voluminous was the evidence that such scientists as Jordan, Gilbert, and Harkness were convinced of the justice of the plea.

As a number of the larger rookeries were situated on federal lighthouse reservations, the commission wrote to the Hon. Lyman Gage, then Secretary of the Treasury, to ask permission to kill sea-lions on these reservations, giving quite fully the reasons advanced for making such a request. The request was granted on April 27, but on May 31, before any lions were killed, the permit was suspended. On June 9 a letter from the Treasury Department gave the information that the suspension was due to protests from the United States Fish Commission, the secretary of the United States Department of Agriculture, the New York Zoological Society, and various others.

The commission in reply stated its case at greater length, and called the attention of the Treasury Department to the fact that while their evidence was backed up and accepted by scientists who had studied the question at first hand, all of the opposition came from men who had no personal knowledge of the various aspects of the question. This reply was sufficient to convince the United States Commissioner of Fisheries, who therefore withdrew his opposition. However, it failed elsewhere, and consequently the Lighthouse Board refused to cancel the suspension until further evidence was deduced.

The case of the commission, of which A. T. Vogelsang was chairman, may be stated briefly as follows:—

Previous to 1884 sea-lions were killed for commercial purposes. Cheaper substitutes have been obtained for the hides, oil, and trimmings, and commercial killing is no longer profitable. Since that time the animals have greatly increased in number, and hence the amount of destruction has greatly increased. They chase the salmon for a long distance up the bays and rivers. "They are voracious and destructive to the last degree. It is estimated by the fishermen upon the rivers, and the salmon canners, that from 20 to 40 per cent of the fish entering the bays are destroyed by this means. They enter the nets of the fishermen and take the fish already gilled. They tear and destroy the nets and cause irreparable damage to the hardy and industrious fishermen. They are seen every day during the salmon run with fish in their jaws and almost no net is hauled that does not show a large percentage of fish destroyed by these animals. It is so now that the fishermen, when laying out their nets, must patrol them from end to end as they drift with the current or tide, armed with Winchester rifles, to protect the nets from the depredation of these beasts." There is little use in providing hatcheries to increase the supply of salmon if the sea-lions are allowed to kill so many of them in the sea. Captain Butwell, chief lightkeeper at Año Nuevo island, in the summer of 1899 made an examination of the stomach of a large grey sea-lion (*Eumetopias stelleri*) and found over sixty pounds of fish bones. In the following summer a deputy killed a sea-lion with a salmon in its jaws, the head of which sea-lion is now preserved at Stanford University.

The case of the opposition is presented most fully by W. T. Hornaday, as representing the New York Zoological Society. He says:—

> "Judging from all the facts which have been brought forward up to this date, and from correspondence with naturalists from the Pacific coast, we

feel constrained to say that, in our judgment, the evidence against the destructiveness of the fur seal is very far from being sufficient to warrant the California Fish Commission in asking the United States Government to permit the destruction on its reservations." He blames the California Commission for condemning the sea-lion on what he considers unsatisfactory evidence. His reasons are summarized as follows:—

"*First.*—We have good reason to believe that the estimated number of sea-lions on the Pacific coast (10,000) is very greatly in excess of the actual number.

"*Second.*—The estimate of the amount of fish consumed daily by the sea-lion herds (500,000 pounds) we consider to be preposterous and absurd. This presupposes that each sea-lion consumes 50 pounds of fish per day, whereas, the full ration of an adult male sea-lion in captivity amounts to only 12 pounds or less per day.

"*Third.*—In the absence of statistics based on detailed scientific observation of known reliability, the assumption that the sea-lions are responsible for a marked decrease in the fish supply of the Pacific coast is unwarranted.

"*Fourth.*—The people of the whole United States have proprietary rights in all the living creatures which inhabit the waters of the coast of California, as well as all other states, and particularly the sea-lion herds which breed on the public domain; and the people of California have no right, either in law or equity, to wantonly destroy the sea-lion herds until the justification of such a course has been clearly and satisfactorily proven.

"*Fifth.*—The sea-lion has been condemned by the California Fish Commission without having had the benefit of counsel or witness for the defence, a proceeding so thoroughly un-American that the findings based thereon are unworthy of serious consideration."

In view of these reasons he asked for the preservation of "the very interesting and valuable sea-lion herds of the Pacific coast."

Mr. Vogelsang, in direct reply to Mr. Hornaday, says that the fifth reason is entirely untrue, as he has shown in his correspondence that all evidence available was considered, some of this evidence from scientists of repute. He objects to the statement that sea-lions are valuable, and as far as the interest goes, they cannot be considered more interesting than other harmful animals, the coyote for instance. He indicates the weight of such remonstrance by saying: "It seems to me remarkable that your society is not aware of the fact that the fur seal does not frequent the rookeries of the California coast, and the varieties against which our activities have been chiefly directed are the barking sea-lion (*Zalophus*) and, incidentally, the grey sea-lion (*Eumetopias*)."

The commission was so confident of the correctness of their stand that they published all this correspondence in the matter and left the public to judge.

Before going further it should be stated that throughout this California report reference is made to two species of sea-lion, the barking sea-lion (*Zalophus californianus*) and the grey, or Steller's sea-lion (*Eumetopias stelleri*), but the general statements apply to both of these. There is evidence that both are found in British Columbia waters, but although *Zalophus* has been reported, it may be only an occasional visitor (see further evidence in this report). The grey sea-lion is the common one on the British Columbia coast and northward.

While the controversy was going on between the California State Commission and the Treasury Department, in the summer of 1899, Prof. L. L. Dyche, of the University of Kansas, made examination of the stomachs of several sea-lions killed

in the vicinity of Monterey, finding in the cases where the contents were suitable for identification, these consisted largely of squid. No traces of salmon were found.

A reference to this work of Dyche's, which was made in an article by C. H. Merriam appearing in *Science*, May 17, 1901, has been very extensively quoted in support of the contention that sea-lions are of little detriment to the fishing industry. Without in any way questioning the results of the investigation, it may be pointed out that these results do not necessarily have much bearing on the sea-lion question in British Columbia. We have no evidence that the grey sea-lion is ever found as far south as Monterey, although it is quite possible that some individuals from the rookery at Año Nuevo or even from that at the Farallones may pay visits to that region. On the other hand, at that time the California sea-lion was found in large numbers around Santa Cruz island, a short distance north of Monterey, and at many points to the south of this. There is every likelihood, therefore, that the majority, if not all, of the animals examined by Dyche were of the California species. Colour is given to this conclusion further by the statement of the United States Commissioners, later referred to, "that the Steller sea-lion is largely a fish consumer and the California sea-lion is largely a squid eater," this statement, of course, being based on the evidence they were able to obtain at that time. It is the Steller sea-lion, almost entirely, with which we are concerned.

On account of further refusals of the Lighthouse Board in 1900 to cancel the suspension of the permit to kill sea-lions on the federal reservations, in 1901 the California commission asked for the appointment of a special commission to look into the matter thoroughly. The request was granted. Cloudsley Rutter was appointed chairman of the commission, R. E. Snodgrass was named by the California commission, and E. C. Starks by the California Academy of Science. This commission visited points along the coast from Monterey to Puget sound, making personal observations and obtaining information from those having personal knowledge of the subject. The report of the commission was submitted to the United States Fish Commission, and appeared in the report of the commissioner for 1902, pp. 116-119.

The following remarks bear on *Eumetopias*. Eighteen stomachs were examined, of which thirteen contained food. All of these had eaten fish, and five of them had also eaten squid, but the fish was relatively large in amount, up to 35 pounds, while the squid was small, six being the greatest number in any stomach. "This study indicates that the Steller sea-lion is largely a fish consumer and the California sea-lion is largely a squid eater. It seems apparent, however, that either species feeds on whatever is most convenient."

"At the mouth of the Columbia river, sea-lions were seen fishing in considerable numbers near the jetty at the mouth of the river, but none was seen to catch a fish of any kind. Gulls were frequently observed hovering about a group of sea-lions and acting as if picking up food. One such flock of gulls was seen coming gradually nearer the jetty from a group of sea-lions about a mile away; after a time it was shown that they were following a large piece of salmon flesh, which the tide brought within 20 feet of the observer. Salmon were seen and photographed that had been mutilated (presumably by sea-lions and seals) after being caught in gill nets. Such mutilated specimens were common. The fishermen stated that the seals simply pull off the gills but the sea-lions always take a bite out of the belly of the netted salmon. A number of pound nets were visited, but no sea-lions were seen in them.

"The fishermen were unanimous in their denunciation of the sea-lions. A fishing company at Chinook, Washington, states that it was damaged $1,500 in 1901 by sea-lions letting fish out of the nets, the damage to the nets not being included. The sea-lions enter the traps in the same way that the fish do, and, after eating what they wish, break their way out through the side.

"The shallow water and the large number of salmon at the mouth of the Columbia river make that point a favourite breeding ground, and there is no doubt that the sea-lions are doing much damage there."

Although permission to kill sea-lions on federal reservations was refused, the commission, by means of arming their patrols, killed a great number of sea-lions at other points along the coast. The report states: "It may be added that our activities have been exerted, nevertheless, to the destruction of a large number of these animals upon such rookeries and other places along the coast as are not subject to the control of the Treasury Department of the United States. The effect on the salmon industry is already apparent, as, since the summer of 1899, the number of sea-lions present in the bays and rivers has been much less than formerly." Apparently the number killed by the patrol was greatly augmented by the number killed by the fishermen themselves.

The destruction at that time seems to have had the desired effect, as since then no serious complaint has been made to the commission. We have this on the authority of Mr. N. B. Scofield, who was in 1898, and is now in 1916, in the employ of the California Fish commission. Sea-lions have been so reduced in numbers that in 1909 a law was passed, forbidding the killing, maiming or capturing sea-lions, in the waters of Santa Barbara channel and on the land adjacent thereto, in order to prevent the extermination of the black or California sea-lion.

As evidence that California was not alone in the demand for reduction in the number of sea-lions, it may be stated that the Oregon Legislature passed a Bill, offering a bounty of $2.50 for each sea-lion killed in the waters of the state or within one marine league of the shore. On account of faulty wording of the Bill, the money was not available, but the Fishermen's Protective Union raised a fund by private subscription to hire men to shoot the lions on their breeding grounds. In Washington, too, there has been some complaint at times but nothing definite seems to have been done.

3. PREVIOUS WORK ON THE SEA-LION QUESTION IN BRITISH COLUMBIA.

So far as is known to the present commission, the only investigations hitherto made in British Columbia are those which were conducted by the chairman and his son, in the year 1913. In the spring of that year, the chairman was requested by the British Columbia authorities in Victoria, B.C., to conduct an investigation to disclose the numbers of sea-lions that frequent and breed upon our coast, and the number and locations of the islands where they breed. This was in consequence of the many complaints made that sea-lions were seriously damaging the fisheries.

No information whatever was furnished to those in charge of this inquiry of 1913 relating to previous controversies regarding the food habits of sea-lions in California or other states, but before starting for the north, such literature as was accessible was consulted, and an examination was made of the report of the United States Commissioner of Fisheries for 1902, to which reference was made by Hornaday and others when describing the California and Steller's sea-lion. This report at once revealed the widely divergent opinions entertained by competent naturalists as to the food habits of the sea-lions, and special pains were taken in the field to procure from all sources information as to their food, and the evidence of the older Indians, who in their younger days had depended largely on sea-lions for food, and had utilized their skins and other parts in various ways, was noted.

The result of the inquiry made by these investigators is mentioned in the annual provincial report for the year 1913, published in 1914. The ground covered by it included the coast line from Boundary bay, North Latitude 49°, to the Nass river in 54° 40′, at various points in which the officials of more than thirty salmon canneries and herring plants were personally interviewed, and further information was obtained from their employees, both white and Indian. Amongst these points were the lower Fraser river, Knights inlet, Alert bay, Quathiaski cove, Rivers inlet, Bella Coola, Kimsquit, Namu, Bella

Bella, Skeena river, Nass river, Masset, Skidegate, Quatsino, Ucluelet, and the important cannery known as Kildonan, at Uchucklesit, Barkley sound. As the result of inquiries at these stations it was learned that serious complaints of depredations by sea-lions were made at only two localities, viz., Rivers inlet and Barkley sound. In each of these places damage had been so great that active steps had been taken to diminish their numbers by the fishing companies affected. Indians questioned at more than forty villages were unanimous in stating that the principal food of sea-lions was fish, and that these fish consisted in the greater part of fish eaten by man, especially salmon, herring, and halibut. In not a single instance was any wish expressed that sea-lions should be protected, as no dependence is now placed on them for food, clothing, or any of the native arts or industries.

Over 1,800 miles of coast line were examined, mostly in a small gasolene sloop. Three groups of islands, forming breeding places, were noted, and a fourth indicated, and the number of individuals seen was estimated at upwards of 11,000. In addition to the rookeries, a large number of isolated rocks, used as resting places, were visited and recorded. The rookeries and hauling-out places were shown on a map accompanying the report.

Later in the season a second visit to the rookeries in Queen Charlotte sound and off cape Scott was made. A number of successful photographs were taken, islands not before visited were explored, and an estimate made of the numbers frequenting these. The joint report shows that the injury to the fisheries complained of is of two kinds. At Rivers inlet the complaint was that nets were damaged and destroyed and vast numbers of salmon were devoured or mutilated, while at two localities in Barkley sound it was stated that the principal loss was in the herring fishery, which suffered largely through the presence of great bands of sea-lions surrounding the schools of fish and driving them out from the heads of bays and inlets where the most successful fishing had always been carried on. Complaint was also made that they devoured enormous numbers of herring and halibut.

As regards the food question, little information was obtained by personal observation. Three adults were examined, two of which contained no food whatever in their stomachs, while the third was full of fish, including salmon, cod, and bass.

A second kind of sea-lion was reported by Indians of Barkley sound as occurring there, and from their description it was concluded that this was the California species, *Zalophus californianus*. It is surmised that this species and perhaps the majority of the individuals belonging to Steller's species came from the American side, as the rookeries in the state of Washington are far nearer to Barkley sound than those on the Canadian side.

4. THE CALIFORNIA SEA-LION IN BRITISH COLUMBIA WATERS.

The following notes tend to confirm the statements made by Indians of Ucluelet in 1913, that a second kind of sea-lion visits Barkley sound at times, though never in large numbers.

Dr. C. H. Townshend, Director of the New York Aquarium, permits the quotation from a letter written on November 9, 1915, of a passage relating to a period when he was the naturalist on the United States Bureau of Fisheries steamer *Albatross*:—

> "I visited Barkley sound in 1889 with the *Albatross*. The sea-lions I saw and heard barking at the time were on some rocks, I think not far from the lighthouse. They were unquestionably the California species, which is the only barking sea-lions in that region. Sea-lions do a good deal of moving about up and down the coast. They do not confine themselves to any one neighbourhood."

Dr. Townshend also sent, at the same time, a copy of the Bulletin No. 29, of the Zoological Society of New York, for April, 1908. This contains an interesting article by Dr. Townshend entitled "An Inquisitive Sea-lion," describing the behaviour of a young specimen of *Zalophus californianus,* which was attracted to the *Albatross* while at anchor one evening at Port Townshend, by the barking of a setter dog. It spent the night in the ship's dinghy, and Dr. Townshend was able to make a very successful photograph of it before it grew dark. The photograph is reproduced on page 412.

Further information of similar bearing was obtained from Prof. Trevor Kincaid, of the University of Washington. At the Alaska-Yukon-Pacific Exposition, held in Seattle in 1909, two animals were included in one of the exhibits, as fur seals. Prof. Kincaid was asked to examine them, as there was much doubt as to the correctness of this designation. Both of them were found to belong to the California species of sea-lion, and those in charge of them stated that they had been taken in the salmon traps at New Dungeness, not far from the entrance to Puget sound. After the close of the exposition the two animals were moved to the zoological collection at Woodland park, Seattle, still labelled as Alaska fur seals. A visit was made by a member of this commission to the Zoological Garden mentioned, and the caretaker was interviewed with little result. The animals in question had died soon after their arrival at Woodland park.

In December, 1915, Indians employed in hunting for the commission, stated that the second kind of sea-lions was well known in Barkley sound as the black or barking kind, but these only pass in as far as Alberni canal very seldom. The last one that was recalled had been killed off Nahmint about five years ago.

5. THE SEA-LION QUESTION AS IT AFFECTS BRITISH COLUMBIA.

At the preliminary meeting of the commission in August a decision was reached as to two main methods of seeking information on the sea-lion question. The one was to make a trip along the coast to get personal information if possible, although little was expected on account of the lateness of the season, and failing this, or supplementing this, to get information from those who claimed to have firsthand knowledge concerning the habits and food of the sea-lions as well as the nature and extent of their depredations. The other was to obtain information by correspondence with cannery managers, fishery officers and others interested or likely to be able to furnish such.

In connection with the former of these, the Department of the Naval Service kindly put at the disposal of the commission, for three weeks, the steamer *Malaspina,* Captain Holmes Newcomb commanding. The commission is under no little obligation to Captain Newcomb, his officers and crew for the courtesy shown during the trip.

On August 30 the *Malaspina,* with Drs. Newcombe and Fraser on board, started northward. The attempt to visit all of the rookeries along the coast had to be given up through lack of time, partly due to delay by smoke and fog, and by waiting for a chance to coal at Prince Rupert. The Cape St. James rookery was not visited, nor was that on the Cape Scott group of islands; three attempts to get out to the Haycocks and Triangle islands all failed on acount of foggy and heavy weather. The rookery on the Sea Otter group was visited, where there were sea-lions visible, but on account of the dangerous reefs in the vicinity, it was not possible to get close enough with so large a boat to make an estimate of the number, and the swell was too heavy to attempt it with a small boat. A small rookery at the west end of Hope island was visited, and here the only attempts made to capture sea-lions proved abortive. On two mornings in succession Indian hunters, hired for the purpose, tried to shoot and spear one or more of the herd of forty or fifty that were visible in the surf, but without

success. Finally the rookery at Solander island, off cape Cook, was visited. The weather was very foggy, but after waiting for an hour and a half in the vicinity, the captain was able to bring his ship near enough the rocks to make the sea-lions plainly visible. The number was estimated to be at least 1,000, although it may have been somewhat in excess of that number. Dr. Newcombe, in his report in 1913, did not consider Solander island to be a rookery but as shown elsewhere in this report, he is now convinced that it is one.

6. INFORMATION FROM EYE-WITNESSES.

As the personal information on this trip, consequently, was somewhat limited, as much as possible was made of the evidence of eye-witnesses. These may be divided into three classes: (1) Those who were not sufficiently familiar with sea-lions to be able to distinguish them from hair seals, (2) those who claimed to have personally seen sea-lions chasing and eating some species of fish, (3) those who claimed to have seen sea-lions eating fish and had also examined the stomachs of one or more of these animals.

Of group (3) the majority were Indians, some of them old men, who, in earlier days, had made use of many portions of the sea-lions for various purposes. Besides these there were two white men, viz., Mr. F. Inrig, manager of the British Columbia Packers' cannery at Wadhams on Rivers inlet, and Mr. J. Boyd, Fisheries Overseer at Bella Bella. Group (2) included cannery men, cold storage men, active fishermen, sea captains, fishery officers, as well as others, in no way directly connected with the fishing business. The evidence of those in group (1) has not been considered.

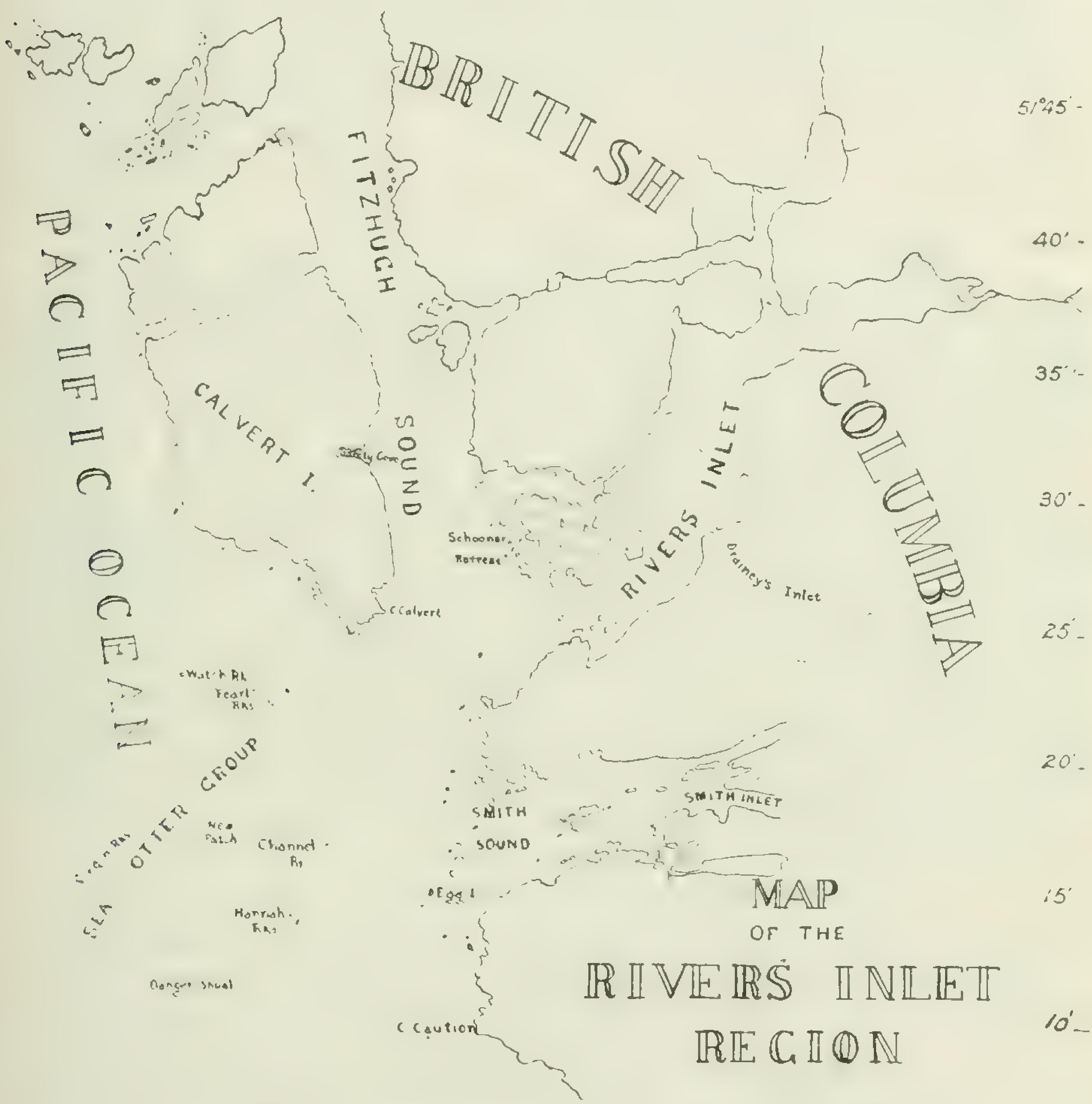
Representatives from numerous localities from Alert bay to Prince Rupert, and all along the west coast of Vancouver island from cape Scott to Barkley sound supplied information for this area and even beyond it to the mouth of the Nass river and Hecate strait. Twenty-six in all made statements sufficiently definite to be worthy of consideration. The commission does not vouch for any of the evidence submitted, but sees no reason to doubt its accuracy. The points at least on which there was general agreement must be accepted until such times as they can either be corroborated or disproved. Already a portion of the evidence has been confirmed as shown in a later portion of the report.

7. MATERIALS USED BY SEA-LIONS AS FOOD.

There was not a dissenting voice to the assertion that sea-lions eat food fishes. Of the food fishes eaten, salmon and halibut have been most frequently noticed, and of the species of salmon, spring, sockeye and coho. Humpback and dog salmon were not reported. Besides the salmon and halibut, other food fishes, viz., herring, oolachan, red cod, ling cod, and rock cod were mentioned. Devil fish (which probably included squid also) were frequently mentioned, dogfish and birds in a single instance. It may be well to note here that lack of positive evidence is not negative evidence. These men, almost without exception, stated that they saw no signs of sea-lions chasing other than food fishes or of the remains of other than food fishes in their stomachs. Naturally so, because in the first place they would never take the trouble to learn the haunts of fish not suitable for food, and in the second place, the sea-lions would be killed almost entirely in the neighbourhood of fishing grounds of some sort, and would more likely than otherwise have eaten those very food fishes. This does not prove that the sea-lion does not eat anything else in the sea when the food fishes are not readily available. This matter is taken up again later.

8. INJURY TO THE FISHING INDUSTRY.

With regard to the injury done to the fisheries of the province, only the salmon, halibut, and herring industries need be considered. Taking first the salmon fishery, the complaints of injury were almost wholly confined to the Rivers Inlet region. Here the sockeye season is at its height just after the pupping season, during which period it has been stated by many authorities, no food is taken by the adults. When the pups are two or three weeks old, according to the Indians, they are able to swim at the surface of the water and are then taken by the adults into the neighbouring waters



while the latter satisfy their appetites, now especially voracious after the long fast. It is quite probable that the amount of the stomach content at that time (Mr. Inrig reported having seen thirty-six sockeye salmon in one lion's stomach) cannot be taken as typical for the whole year.

The sea-lion is such a powerful swimmer that it can readily overtake a salmon, which it catches and shakes until the piece comes out and the bite is swallowed. If the fish are plentiful, the bitten fish is not touched further but another is attacked in a similar manner. If the fish are scarce the part of the fish left after the first bite

may be seized again by the same individual or by other individuals, as they commonly go hunting in small herds. At times they find it more convenient to take the salmon out of the gill-nets, especially when they are being hauled, as then the fish are near the surface of the water. One case was reported where sixteen salmon in succession were taken, as fast as the net was hauled to the surface, the one animal making the entire capture. It is at such times that harm is done to the gear. The lions are so powerful that if the net is taut they pass through it with ease. If it is looser they may get tangled up in the net and do much more damage to it.

The rookery in the Sea Otter group of islands is opposite the mouth of Rivers inlet, (see map, page 13), so that all schools of fish entering the inlet must pass near by. The sockeye run comes just at the time when the lions need the greatest supply of food, hence what could be more opportune for them.

Apparently in the early days of the industry the sea-lions were not so numerous. It was not until about 1911 that they appeared in large enough numbers to be especially troublesome. In 1912 and in 1913 so many fish were taken from the nets set in the inlet for some distance from the mouth that the fishermen found it useless to continue fishing in that locality. Many of the sea-lions were killed in 1914 and 1915, and the season of 1915 was a particularly good one in the inlet.

The injury done to the halibut fisheries has not been so serious, partly because the habits of the halibut require a different method of fishing. The attack made on an individual of this species can only be observed when a halibut is taken from the hook when that part of the line is near the surface, at which time the halibut is attacked in the same way the salmon is. Damage was reported from Hecate strait and from the area to the north and northwest of Vancouver island. In fishing for this species there is little chance for any damage to gear.

Damage to the herring industry was reported only from Barkley sound. Here the complaint was not so much that the numbers of the herring were being diminished as that the schools are broken up, scattered and driven seaward. As many as 300 sea-lions have been reported from the sound where they use the Bird rocks for a hauling-out place. Two plants have been in operation, one at Ucluelet, near the entrance, and the other at Uchucklesit, far up the sound. Barkley sound is a long distance from any known rookery, but as the lions do not appear here until late in the fall, the pups no longer need care, and as the adults are such powerful swimmers such distances would not mean much to them. In other localities, notably Clayoquot, Quatsino sound, and in the Nass river, herring runs are followed by sea-lions, but as yet not enough fishing has been done for any special observation to be made.

9. THE FLATTERY ROOKERY.

This Malaspina trip covered the "spheres of influence" of all of the British Columbia rookeries, but it was possible that it did more than that. Barkley sound is a long way from Solander island, where, so far as is known, the nearest British Columbia rookery exists. It is much nearer to what is generally spoken of as the Flattery rookery, off the west coast of the state of Washington. It is probable that occasional sea-lions seen in the strait of Georgia, as far north as the mouth of the Fraser river and at Entrance island, near Nanaimo, as well as others in the strait of Fuca, are from the Flattery rookery. On that account it seemed desirable to obtain more definite information concerning this rookery.

Mr. John N. Cobb, editor of the *Pacific Fisherman*, who has shown much interest in the work of the commission, obtained the assistance of the United States Revenue Service, who kindly placed the *Snohomish*, Lieut. H. W. Pope commanding, at the service of its members, for the purpose of visiting the rookery. As the State Department was also interested in the information, Mr. Cobb went along to represent that department.

On October 25, Mr. Cobb and Drs. Newcombe and Fraser met the *Snohomish* at Port Angeles and proceeded to Neah bay, where the night was spent in order to make an early start in the morning to visit the rookery. In the morning, however, such a storm was raging outside the cape, that visiting the rookery was out of the question. The next day was no better, and hence the visit had to be abandoned. The trip was not entirely in vain notwithstanding, as from the Indians at Neah bay it was learned that the rookery in question is located on the Jagged islets, about nine miles south of the Umatilla reef, or twenty-one miles south of cape Flattery. Judging from some photographic prints of the rookery that were shown, it must be quite a large one. The Indians, too, gave the impression that it was of large size although no definite estimate could be obtained from them. From this rookery the sea-lions come out into the strait of Fuca, haul out on rocks not far from Neah bay, and even come into the bay itself after fish. The Indians here had the same story to tell concerning the eating of halibut, salmon, and herring.

10. BARKLEY SOUND INVESTIGATION.

In order to obtain more definite information as to the damage done by Steller's sea-lion than that afforded by the statements of white and Indian fishermen, certain arrangements were made with Mr. Martin, manager of the Wallace Fisheries Company at Kildonan, Barkley sound. Mr. Martin courteously afforded every facility at his disposal at the cannery, and the commissioners had such an excellent base of supply provided for them that it was unnecessary to take any camp outfit.

Two points of special interest were to be taken up. The first was with regard to the interference by sea-lions with the herring fishery in the way of keeping these fish off-shore, or by breaking up the schools; the second was with respect to the statement that they annually devour large quantities of herring.

In 1915, the sea-lions made their first appearance for the season in Barkley sound on November 1. On the morning of November 3, Dr. Fraser, being provided with a motor-boat and two men from the cannery, was able to visit their hauling-out place on Bird rocks. Small groups were seen from the entrance of Uchucklesit harbour to Bird rocks, and on the rocks there were about sixty, but these fell off into the water before it was possible to get a shot. It was an easy matter to chase small herds, up to ten or twelve, for a long distance, as they kept together well, coming to the surface often. Some shots were fired, but as no means of retrieving them were available at the time, no specimen was obtained. Some photographs, indicating their presence, were obtained, but otherwise these do not give much information. Apparently all of these lions were of the Steller species, and there were no small ones in the lot.

On the following morning, on the way from Kildonan to Port Alberni, small groups of lions were seen at intervals from the mouth of the harbour almost as far as the Canadian Northern construction headquarters. In every locality in which they were seen there was every evidence of herring schools there also.

From reports received by the chairman early in December, it was learned that sea-lions were in great abundance in nearly all of the numerous inlets branching from the larger waters, known as Barkley sound, and that they were as usual pursuing the herrings, which were then being taken for curing and for bait. As stormy weather then prevailed, causing wrecks and loss of life just outside of the sound, it was thought that a more successful hunt could be made in the more inside waters of Uchucklesit inlet. As Dr. Fraser was out of the province at the time, and Mr. Greenwood's engagements prevented him from taking part in the investigation, the consideration of the food question as far as these Barkley sound sea-lions were concerned was undertaken by Dr. Newcombe alone.

It was a matter of congratulation, however, that Mr. Clyde L. Patch, Dominion taxidermist, was able to take an active part in the investigation. Hearing from the chairman that an attempt was to be made to secure a large number of sea-lions (including, it was hoped, the California species), Mr. Taverner, zoologist of the Royal Victoria Museum, Ottawa, supported by the Director of the Geological Survey, Dr. R. G. McConnell, offered to send a skilled taxidermist, with a view to saving all skeletons and skins for permanent preservation as a mounted group. Mr. Patch co-operated heartily in the work of collecting specimens, and, in spite of very adverse weather conditions, secured the desired parts of fourteen individuals, together with data as to sex and size. He also made plaster casts of various parts, to be utilized when mounting these specimens.

MAP OF THE BARKLEY SOUND REGION

On arriving at Kildonan, a short distance inside of Uchucklesit inlet, on December 16, it was found that the herring and their pursuers were no longer there; they had been for some weeks, but had passed out into the sound. Native hunters were secured, and a small gasolene fish-boat was hired, in preference to the large craft, the loan of which was offered by Mr. Martin. The two Indians were armed with rifles and with the ordinary fur-seal spears of the west coast, in order to retrieve the bodies of any wounded individuals. Independent Indian hunters were also promised a certain sum for every sea-lion they could secure.

The first goal was the Bird rocks, the principal resort and retiring place of sea-lions in Barkley sound, where, it was stated, a day or two earlier, some hundreds had been seen from passing vessels. On the way out two independent hunters in a small canoe furnished with gasolene were overtaken. They had just wounded a female sea-lion, and speared it while under observation.

At Bird rocks there was a large number of sea-lions, some hauled up, and a large number swimming about close to the shore. All were somewhat wild, but two were killed and hauled on board to be examined at leisure at Kildonan. The weather was dull and rainy, and hence it was impossible to secure successful photographs. After this the hunting was left to the Indians to carry on, resulting in eleven more specimens being brought in, two of which were paid for by Mr. Patch on behalf of the Geological Survey, as the chairman considered that a run of eleven or twelve specimens, all telling the same story, was sufficient for the purpose of the commission.

On opening the stomachs of the twelve specimens containing fish, it was found that all of them had herring in an unmutilated condition. Evidently they had bolted them without any mastication. The quantities amounted to from one-half to two gallons, including the pulpy mass of more or less digested food. Two contained one or two rounded stones.

The following table shows the sex, length, etc., of those examined, as noted by Mr. Patch:—

No.	Where Killed.	Sex.	Length.	Stomach Contents.
1	Bird rocks	Male	8 ft. 4½ in.	Small crabs, devil fish.
2	"	"	9 " 5 "	Stone, clam shell.
3	Off Uchucklesit	Female	8 " 3 "	Herring.
4	"	Male	9 " 2¼ "	"
5	"	"	6 " 10 "	"
6	"	"	8 " 11 "	"
7	"	"	8 " 2¼ "	"
8	"	Female	8 " 3½ "	"
9	"	Male	8 " 2 "	"
10	"	"	7 " 3½ "	"
11	"	"	8 " 8 "	"
12	"	"	7 " 11 "	"
13	"	Female	8 " 3¼ "	"
14	"	Male	10 " 4½ "	"

In addition to these fourteen, a male brought to Kildonan a few days previous to the arrival of Dr. Newcombe and Mr. Patch, was opened and examined by Mr. W. A. Newcombe, who reported that it had been killed amongst the herring, and that it contained a large number of these fish and their skeletons, in addition to a pulpy mass of indistinguishable material.

From the results above detailed it seemed clear that at this time of the year, at least, the main food of Stellar's sea-lion, while in Barkley sound, is one of the most important food fishes of the province, and that the contention of the white and native fishermen relating thereto was amply supported by incontestable evidence.

Some of the stomach contents were bottled up and sent to Dr. Fraser for examination, on which he reports as follows: The main portion of the material from sea-lion stomachs sent from Barkley sound consisted of herring in a more or less digested state, but the other contents are worth considering. These were (1) the dorsal fin and some vertebræ of dogfish—enough to make diagnosis definite; (2) a portion of a vertebral column of a flatfish—not enough to make identification of species possible; (3) a clavicle from some bony fish, possibly from the same flatfish; (4) a number of cephalopod beaks; (5) a clam shell that had been bored by *Thais*; (6) small stones; (7) numerous nematode parasites of the Ascaris type.

The finding of the dogfish remains is especially interesting. Only one of all the eyewitnesses examined mentioned dogfish as an article of sea-lion diet. In recent years the dogfish have been so numerous in Barkley sound during the early part of the herring season that the fishermen find it unprofitable to put out their nets since the dogfish do so much damage to them. It may be only a coincidence, but when the sea-lions come in about the first of November, the dogfish no longer interfere with the nets. The fact that sea-lions do eat dogfish indicates that it might be more than a coincidence. Without question the dogfish is a greater pest than the sea-lion at the present time. It might be a still greater pest if the sea-lion were exterminated.

The flatfish remains, as well as those of the squid and devilfish, indicate that at times the sea-lion is a bottom feeder, possibly only in shallow water. The dead clam shell and the stones were likely scooped up when the bottom feeding was being carried on.

From the variety obtained in two of the stomachs it seems as though the sea-lion is not restricted in its diet but that anything will serve, the most abundant material receiving the greatest attention.

11. INFORMATION BY CORRESPONDENCE.

While the investigation in the sea-lion haunts was being carried on, the secretary was getting information by correspondence. To facilitate and unify this, a set of questions, accompanied by a circular letter (see appendix), was sent to each British Columbia cannery manager, etc., who was likely to have knowledge of any phase of the question. To these questions a large number of replies were obtained, and these, in general, definitely confirmed the evidence already quoted, and brought out some points not previously considered.

Comparatively few endeavoured to estimate damage to gear, but the total estimates given amounted to over $1,600 for the year 1915. It was scarcely expected that any very definite figures would be given for the value of the fish lost by mutilation or for the diverted run of fish but a number of replies indicated that in the case of the salmon, the value of the fish lost by mutilation, and in the case of the herring, the value of the loss by diverted run, would be considerable. The only place where any definite change in the number of sea-lions was noted was at Rivers inlet, where there was a definite increase during 1911-12-13, and since then a noticeable decrease.

None of those directly interested in the fish business could give any definite information as to the value of sea-lions. Such information from other sources will be treated separately.

The correspondents were almost unanimously in favour of complete extermination, to ensure which they wished a Government bounty, none of them feeling able to cope with the situation themselves. That extermination might be as rapid as possible, shooting the adults and clubbing the pups on the rocks soon after they were born in June, should afford the most definite results, although poisoning and other extreme methods were also suggested. These methods would not do very well in Barkley sound where the sea-lions come in late in the fall. As a bounty mark, the muzzle seemed to satisfy the majority, although it was also suggested that the mark should be changed from year to year.

12. KILLING SEA-LIONS.

Nothing was done systematically towards the killing of sea-lions, except in Barkley sound, where it has been going on with more or less vigour for several years, until the year 1914. So much damage was done to the fisheries of Rivers inlet in 1913 (Manager Inrig estimated the loss of gear at Wadham's cannery alone at

$3,021) that the following year several cannerymen decided to co-operate in decreasing the number. A levy of $1.50 was made for each boat fishing, and as there were 700 boats fishing, this provided a fund of $1,050. Two dollars a tail were offered for sea-lions, and in thirty-six hours enough tails were obtained to take up all the bounty, that is to say 525 were procured.

During this year again, on Barkley sound, men were supplied with guns and ammunition and sent to drive the sea-lions away from the schools of herring. They can be chased thus like herds of cattle. No effort was made to retrieve any of those shot, but a large number must have been killed.

In 1915, Wadham's cannery supplied two gasolene fish carriers, and giving twenty men to each a holiday, armed them with rifles and supplied them with between $400 and $500 worth of ammunition, sent them off to the rookery to kill sea-lions. The first trip was made in the second or third week in May, and a thousand rounds of ammunition were used. Hundreds must have been killed, but only three noses were taken home. The second hunt took place in the first week in June. This time 200 muzzles were obtained, and it was estimated that 750 altogether must have been killed. The muzzles were handed in to the fishery officer for the bounty of $2, which was placed on sea-lions last year by the Department of Fisheries, $5,750 being set aside for that purpose. This bounty was all used up early in June, many muzzles being brought in after the bounty money had all been paid out.

Of the 2,875 sea-lions for which bounty was paid, 1,160 were killed at or near the Sea Otter group at the mouth of Rivers Inlet, 1,616 on the East and West Haycocks (islands in the cape Scott group) and the few remaining at various spots along the coast. Beside the number mentioned from the Haycocks, 674 were brought in too late for bounty. (These figures were supplied by Mr. F. H. Cunningham, Chief Inspector of Fisheries, the list including the number to whom bounty was paid, the number and the location where obtained. See Appendix B).

In the two years, therefore, there is positive evidence that 4,074 sea-lions were killed, 3,549 in 1915, and 525 in 1914. According to the statements of Fisheries Overseer Saugstad at Rivers inlet, and Boyd at Bella Bella, through whom most of the bounty was applied for, there would certainly not be more than 50 per cent saved of those killed. Of the adults, there might not be more than one in ten, but among the pups there would be quite a large proportion. Approximately 75 per cent of the muzzles brought in were from pups. In the localities alone in which sea-lions were killed for bounty in 1914 and 1915, at a conservative estimate there must have been 8,000 killed, of which approximately 6,000 were pups. The number killed in Barkley sound and at isolated spots elsewhere would add materially to this number. At such a rate, extermination would not seem far off. In fact it was practical extermination of the 1915 increase on the Sea Otter and Haycock rookeries.

Comparing these numbers with the estimated number for the whole coast, 11,000, given by Dr. Newcombe as seen in 1913, it would seem that an estimate based on the numbers that may be seen at the rookeries and hauling-out places, must be too low. Even during the pupping season, all the lions will not be on the rookeries at the same time, for while the adult male and female may fast at such a time, there is no evidence that immature individuals do so, and the probability is that they feed then as they do at other times of the year. During the rest of the year, it is known that at times all the members of a herd may be away from the rookery or hauling-out place at one time, but there is no assurance that all of them are ever on the rocks at the same time. Certainly there are times when some are on the rocks and others are in the water, since that has been observed by the commissioners on different occasions. If they are not all on the rocks at the same time, an estimate based on the number seen at any one time would not take into account those in the water.

Consider the case of Solander island for example. In the investigation by Dr. Newcombe in 1913, since at times there were no lions whatever visible, doubt was expressed as to its being a rookery (there is now conclusive evidence that it is), although at other times upwards of one thousand were seen there. Even when a thousand of them were on the rocks there may have been many more scattered about, actively feeding or in search of food.

Taking it for granted, therefore, that 11,000 was a fair estimate in 1913 for the number of sea-lions that could be seen at the rookeries and hauling-out places, it is evident that to this number, an addition must be made, amounting to an unknown percentage of the whole number, to get at the total number in British Columbia waters.

13. COMMERCIAL USES TO WHICH SEA-LION CARCASSES MIGHT BE PUT.

From evidence of manufacturers and sea-lion hunters the suggestion was conveyed to the commissioners that there was an economic and commercial value in sea-lion hides, whiskers, and carcasses. Under the bounty system the whole carcass of a sea-lion, with the exception of the muzzle, is disregarded, thrown into the sea, or left on the rookeries or hauling-out grounds to putrify, so far as any effort is made by the Government to utilize it. Much time was spent and many persons interviewed in obtaining definite information as to the feasibility of utilizing sea-lion carcasses for commercial purposes, with the happy result, however, of its being demonstrated that the hide of a sea-lion is eminently suitable for tanning into leather, from which durable and serviceable gloves and boots to-day are being made; that the whiskers have a value of 25 cents a piece to Orientals; and that the flesh can be rendered into oil and guano, for which a good market is ever available. While it was impossible, owing to the short time at the disposal of the commissioners, to investigate this side of the problem in an exhaustive manner, on account of the great distances from Vancouver and Victoria to San Francisco and New York, where comprehensive and accurate corroboration of the commercial uses of the carcasses of sea-lions can be obtained, yet sufficient evidence was discovered to point to the conclusion that in killing sea-lions the economic value of their entire carcasses should be taken into consideration, so that, if it were found possible and feasible, then the monetary returns from the disposal of the carcasses in the form of hides, whiskers, oil, and guano would at least equal and possibly, with care, exceed the amount of the bounty offered by the Government. It is in the mind of the commissioners that if such a consummation could be reached, a real service to industry and the country could be rendered. It is in this direction that the commissioners desire to pursue their inquiries during the coming year.

What turn that inquiry might take is indicated by the fact that Mr. W. F. Robinson, president of the Robinson Fisheries Company, manufacturers, producers, and distributors of fish oil and fish fertilizer, Anacortes, Washington, writing to the commission under date of August 11, 1915, says: "We have never yet had the carcasses of sea-lions to use in our fertilizer plant, but could do so if we had them, as we understand they grow to a very large size. Unless the expense of obtaining the sea-lions is too great, or your works are not near the source of production, we believe they could be handled to advantage."

Messrs. Anderson and Miskin, 448 Seymour street, Vancouver, in answer to an inquiry from the commission, wrote the following letter, in which it is understood that the oil from the sea-lions corresponds to seal oil:—

> "Replying to your telephonic inquiry *re* our requirements of seal oil, we are buyers of the same quality as is produced in Newfoundland from the blubber of the young harps (hair seal). It is principally used in miners' lamps, and must be free of moisture. If we get the right quality, we can use 500 to

700 tons per annum. Samples are usually submitted before we purchase, or it is guaranteed to be the finest quality, and what is termed 'water white.' Straw and coloured oil, which is much cheaper, we handle a small quantity of. Oil from old harps is very much darker than what is produced from the young ones.

"There is a good market for seal oil in United Kingdom, and we have no doubt whatever that, if the stuff can be produced on the Pacific coast, it would be to our mutual advantage. If a small trial lot was sent home on consignment through us, it would enable our friends to judge of the character of the oil, and if not suited for their purposes there would be no difficulty in disposing of it in the open market. If, on the other hand, it did suit them, they would doubtless be willing to make a contract for the quantity we have already stated, under guarantee of quality equal to consignment parcel, of which sealed samples could be retained here."

As to guano obtained from fish, whales, and other sea animals, its price is in the neighbourhood of $40 a ton. It is used as a fertilizer, and also manufactured into chicken food. The demand is steady and growing. Similar guano, it is thought, could be made from the carcasses of sea-lions.

In relation to the manufacture of sea-lion hide products, the commission is indebted to R. C. Grinnell, British Columbia Glove Company, Eburne, Point Grey, for valuable information obtained during an interview on October 22. Mr. Grinnell speaks from personal knowledge as in his factory he has made gloves, boots, and moccasins from sea-lion hides. In fact, he has built up a small but substantial business in leather goods made from sea-lion hides. Naturally, therefore, he is emphatic in his declaration that sea-lions are of commercial value, especially for their hides.

In 1913 he took a hunting trip to Haycock islands and got 500 hides which, when green and salted, weighed almost 200 pounds apiece. These hides he tanned in the ordinary way and made into gloves in his factory which in the fall of that year, was situated at Coquitlam. In tanning the hide reduces about 75 per cent, and when tanned runs from an inch to a quarter of an inch in thickness. It is thin under the flippers but it is thicker on the belly than on the back. In making the hide into leather it may be split into three layers, and when thus split can be readily manipulated. From this leather, chrome-tanned leather gloves are made. From the hide of a fair-sized male, 2½ to 3 dozen pairs of gloves may be made, but taking an average of male, female and pup, only about 25 square feet of leather can be obtained, enough to make one dozen pairs of gloves. The range of gloves made runs from the fine automobile gloves or gauntlets to the heavy loggers' mittens, the former selling at $24 a dozen pairs and the latter from $10.50 to $15. No better material can be obtained for loggers' mittens, as the hide of the sea-lion by nature is of fine fibre, tough, strong, flexible, and of close grain, enabling it to keep out water, while still retaining its pliability. The other gloves as well are very durable and serviceable. On the day following the interview, Mr. Grinnell brought into the secretary's office two pairs of gloves made from sea-lion hide, tanned in his own factory and made up in the interval. One pair was from the hide of a sea-lion pup, this selling at $1.50 or, by the dozen, $12.50; the other was from an adult, selling at $1.75 a pair, or $13.50 a dozen. The secretary bought the two pairs, and has them on exhibition in his office at present. With eight or nine men working, twenty-five to fifty pairs of gloves a day are made. More men are wanted, as the output could easily be increased. Glove business from sea-lion hides is a good business. There is a ready market in Canada for all the factory can turn out.

The moccasins that Mr. Grinnell makes from the sea-lion hides give good satisfaction. They are pliable and fit snugly to the foot. The price is $26 per dozen

pairs. Boots from these hides stand water as well as rubber boots. A pair were made for a customer, who has to wade through water and chemical liquor all the time while at work, and even here they gave excellent satisfaction. For boot purposes, green hides are better than dry hides, but all sea-lion hides are good.

Mr. Grinnell would be glad to consider a proposal to buy all the sea-lion hides that could be delivered to him, and is sure if he could get the supply at a fair price he could build up a large industry. He would be willing to pay 5 cents a pound for green hides if he were guaranteed 5,000 hides. If he could get hides in large enough numbers to make it worth while he could ship them to San Francisco, as he has a standing order to ship any hides he can get at 6 or 7 cents a pound for green hides of females and pups and 2 cents a pound for males, but he has to pay the freight. It would take 5,000 per annum to satisfy this demand.

If the lions can be obtained, the skinning is a simple matter. A good man can skin a lion in from fifteen to twenty-five minutes and should be able to skin three or four an hour. He would thus make good wages if he could get steady work for the day at 25 cents a skin.

Mr. Grinnell is of the opinion that the oil from the sea-lion alone should make it worth while saving the carcass, and the remainder of the carcass made into guano or chicken food should command a good price.

P. H. McMullen, representing the McMullen Hide and Fur Company, 956 Powell street, Vancouver, said he would handle any quantity of sea-lion hides at a price similar to that suggested by Mr. Grinnell.

14. BOUNTY PAYMENTS FOR KILLING SEA-LIONS.

By good fortune the commission interviewed A. K. Sinclair, 2940 Ontario street, Vancouver, a sea-faring man, an old sealer and perhaps the pioneer sea-lion hunter for profit in British Columbia. He tells the sea-lion story from a different viewpoint, that of the hunter. In May, 1914, he was on a hunting trip for Hibbard & Stewart, hide dealers, 958 Powell street, Vancouver, as skipper of the schooner *Tuladi,* the agreement being that he was to receive 3 cents a pound for green salted sea-lion hides, delivered in Vancouver.

He was at Rivers inlet on May 25, 1914, where, he states, he organized the plan mentioned elsewhere in this report by which the canners there gave $1,050 in bounty in an effort to diminish the depredations of the sea-lions by killing off a number of them.

Sinclair had to wait about a week for good weather before he could get on the Virgin rocks. From his anchorage in Schooner Retreat, every day he spied out the land until conditions were ripe. On June 5 or 6 he made a landing on the Virgin rocks from a dory. The sea-lions made as if they would prevent his landing, but after killing five or six of them from the dory he and one hunter succeeded in getting on the rocks. They left one man on the schooner and one man in the dory not far from the rocks. It was breeding season, and all the sea-lions stayed on the rocks when the landing was made. The lions were not frightened, they did not stampede, they seemed indifferent to the visitors. If any sea-lions slid off the rocks on the approach of the hunters they returned to the rocks after the hunters landed.

The hunters shot all the cows and bulls they could within that radius, and cut the tails from all they had killed to collect the bounty. They started killing at 6 in the morning and finished at 2 in the afternoon. At the end of the killing, 750 tails were counted. They then turned back to Rivers inlet, declared enough tails to collect $1,050 and hoping that more bounty might be put up they did not reveal the possession of a greater number.

After Sinclair and his crew had collected the bounty they went back to the Virgin rocks and skinned some of the sea-lions for their hides. They got about 2,000 pounds, when the weather turned bad and prevented any further landings. The wind came in from the west every day about 10 a.m. and kept blowing steadily and strong until evening, when it died down. All that they got from the hides on this trip amounted to $60, but they had the $1,050 bounty money besides.

The following year, leaving Vancouver on May 12, Sinclair with two others took the 40-foot gasoline schooner *Atlintoo* up the coast to hunt for sea-lions. They got a few near Smiths inlet. On May 16 they were off Virgin rocks, but very few sea-lions were in sight. They arrived at Rivers inlet May 20, where they tried to get the canners again to put up a bounty fund, but the canners had decided to go hunting sea-lions on their own account. Sinclair describes the hunting party from the canneries as composed of sixteen or twenty men armed with "pop guns," twenty-two rifles, revolvers, and other firearms. They left Rivers inlet 2 a.m. one Sunday, went to Virgin rocks, and got back about four in the afternoon. They were not successful, as they had begun too early. Four noses were all they had. (The bounty mark had been changed from tails to noses.) Later, many other parties from Rivers inlet went out to Virgin rocks, until from much shooting the sea-lions got scared off. On June 3 Sinclair and his crew got fourteen noses after making a landing on Virgin rocks. He found the sea-lions timid, for as soon as they saw the launch they got off the rocks into the water, and even the mothers left their young when the hunters landed. "The sea-lions went off like sheep." He was dissatisfied with Virgin rocks and went to Calvert island, where he anchored, and got four noses one day, ten another, and eight another. In all he got fifty-seven noses, and landed at Rivers inlet, where he collected on them in the name of George Allen. Fifteen noses he brought to Vancouver and collected on them there.

Mr. Sinclair declares that to make a success of sea-lion hunting it is necessary to be able to land on Virgin rocks every day or every other day. He says that if there had been a bounty in 1914 he could have killed 90 per cent of those on Virgin rocks. If he had been offered $2,500 to clear the sea-lions off Virgin rocks in 1914 and protect the Rivers inlet fisheries he would have accepted it and done the job completely. The proper way to attack these animals to reduce their numbers is to get the old ones first. When females are pupping the old sea-lions never leave the rocks to feed or do anything else. The bull sea-lions are as thin as rakes after the cows are done pupping, at which time they are all very voracious. If it is desired to exterminate the sea-lions, all the rookeries should be hunted at the same time. During the pupping season they are easily fooled, since they persist in staying on the breeding grounds. Sinclair would take six or seven good shots and reach the rocks about June 1. He would hide three men on the rocks with orders to shoot only the old ones and to shoot to kill, aiming at the spot just below the ear. The old ones will not leave the rocks at this time if they are not fired at from the water, and the pups cannot, for they are not strong enough, as they are suckled by the mothers for ten days or two weeks after birth. When the adults are killed the pups can readily be clubbed, and if not they would die of starvation.

Sinclair is of the opinion that bounty should not be paid unless the hide were brought in, as the hide could be sold for more than the bounty. He would be willing to hunt sea-lions, collecting a bounty on the hide of $1 for pups, $3 for females, and $2 for bulls. He says also that bounty paid on sea-lions killed at a long distance from any locality where fishing is in operation is money thrown away. He thinks East Haycocks, Tree Nob island, Butterworth rocks, Massett, Banks island, Price island, Bonilla banks, and Aristazable island are too far away from Rivers inlet to allow sea-lions from them to be the cause of depredations to fishing.

An article appeared in the *Pacific Motor-Boat*, Seattle, Wash., in November, 1915, treating of sea-lion hunting by motor-boat in Oregon, so pertinent to the Canadian

inquiry that, with the permission of the publisher, Mr. Miller Freeman, it is reproduced in part:—

"A rather unique industry is carried on each year in motor-boats off the coast of Curry county, Oregon. The Rogue River reef and the Cape Blanco reef are each year combed for sea-lions, and the work of killing them is often hazardous and dangerous.

"The killing is not done for amusement, but for profit, the skins being valued at from $4 to $6 each, and some other portions of the carcass being of sufficient value to make the average for each animal killed between $5 and $6.

The annual slaughter does not take place until the young are born, usually in July and August. This plan of leaving the pups insures a supply for the hunters the next year and there is no danger of the disappearance of the sea-lions from the vicinity where they are sought.

The largest rocks in the Blanco reef are off shore from three to seven miles and the hunters must go well prepared. It is possible they might be obliged to stay about the rocks two or three days at a time, for the ocean occasionally becomes so rough the small boats are obliged to stay in the lee until the weather improves.

Until late years the hunters used rowboats in which to seek the lions and sometimes were on the rocks several days before they could return ashore at Port Orford, the nearest town. Recently, however, gasoline boats are utilized altogether in hunting. It is customary to go from shore to the rocks where the sea-lions make their home, in a small open craft, and, after making a kill, the skins are picked up from the reef by a larger craft, the gasoline schooner *Tramp,* a 15-ton boat of Marshfield. Captain John Swing has transported the sea-lion hides in the *Tramp* from the two reefs for the past ten years, trans-shipping them for San Francisco at Coos Bay.

The average number of hides secured each season varies from 300 to 400, the hunters feeling they have done a profitable season's work if they make a clear profit of $1,000, since the season is only for a month, and the time goes quickly while they are engaged. The hides are used by manufacturers for belting. They are prepared by salting them heavily but not tanned until they reach their destination at San Francisco. The skins are heavy, the hunters finding them occasionally weighing 150 pounds when secured from an animal of extraordinary size.

Taking the skins from the sea-lions is an occupation that calls for quick and expert ability. A good skinner can take a hide off in from five to seven minutes, when working at ordinary speed. Robert Forty and James Crewe each has a record of skinning a common-sized animal in three and a half minutes. While there is no means of weighing the sea-lions, the hunters estimate their weight from 1,500 to over 3,000 pounds. The larger the pelt, of course, the better the price is secured."

Thus it will be seen that in paying a bounty of $2 for each muzzle of a slain sea-lion and disregarding the hide and carcass, there is lost an opportunity to encourage the prevention of fisheries depredations and at the same time, by means of a business organization centered in the government officials, make the sea-lion, through its hide and carcass, pay the bounty and more. When further facts are obtained concerning methods of organization, aiming at using for commercial purposes the sea-lion carcass, the commission should be able to outline a plan that would achieve that economical and conservative result.

15. CONCLUSIONS AND RECOMMENDATIONS.

The commissioners are satisfied that as the numbers of sea-lions in or near Rivers inlet increased from 1911 to 1913, they were present in sufficient numbers to be a serious menace to the fishing industry, although there was no diminution in the pack until 1913. Thus the pack for 1910 was 129,398 cases, for 1911, 101,066 cases, and for 1912, it amounted to 137,697 cases; in 1913 there were only 68,096 cases put up, the smallest pack since 1901. This was the year in which it was found useless to fish farther out towards the mouth of Rivers inlet than the entrance to Draineys inlet. The fact that the fishermen had to stop all fishing in this region on account of the number of fish taken out of the nets and the amount of damage done to gear is backed up by the fact that the cannery managers of the five outer canneries in the inlet were willing to put up their own money in 1914 as a bounty that the number of sea-lions might be reduced. Coincident with the decrease in the number brought about in this way in 1914, the pack went up again, amounting to 109,052 cases. While the fluctuation from year to year is always evident, the great decrease in the pack for 1913 can scarcely be accounted for on that basis. In 1915 a bounty of two dollars per muzzle was placed on sea-lions by the Department of Fisheries. This might have been expected to help out the Rivers inlet canneries, and probably it did so as the pack 146,838 cases, slightly surpassed the previous high record of 1912. Of this pack, over 130,000 cases were sockeye, over 27 per cent of the total sockeye pack for the province for this year. Since such a pack is worth approximately $1,200,000, it is certainly worth conserving.

However, as this bounty of two dollars was an indiscriminating bounty, its success was not unqualified. It is true that many sea-lions were killed in the vicinity of Rivers inlet, but it is also true, as shown in this report, that more than twice the number were killed at points too far distant from Rivers inlet to have any effect on the fishing there, not because sea-lions, on occasion, do not travel so far, but that at, and for some time after, the pupping season, they remain in the vicinity of the rookery, and this season corresponds with the time of the sockeye run in Rivers inlet. Furthermore, it is commonly believed that the numbers in the Sea Otter rookery have greatly increased since the lions were driven from Triangle island after the erection of the lighthouse and the installation of a wireless plant there. If this is true, the killing of so many sea-lions on the East and West Haycocks in 1915 will tend to drive those uninjured away from these islands and hence it might increase the numbers in the Sea Otter rookery, thus doing harm rather than good to the Rivers inlet fishing. Since only the muzzle was required to obtain the bounty, it was possible for a very few individuals to kill a sufficient number on the rookeries in a very short time to take up all of the bounty, whether these lions were doing any harm or not, consequently, in other cases where sea-lions, likely to be doing harm, were killed, there was no bounty available. As an example, the Barkley sound fishermen had made complaints of depredations by sea-lions but as the whole available bounty was used up in June, while the sea-lions did not come into Barkley sound until the first of November, the Barkley sound fishermen received no benefit whatever from the bounty. If the skins and carcasses had been made use of, such wholesale killing in such a short period would not have been possible, and some return might have been obtained from the money expended.

The opinion is still held by eminent scientific men that it has not yet been proved that fish is an important item of the food of sea-lions. Drs. Merriam, Evermann and Hornaday have been much quoted in this regard. These men and others, during the California controversy, refused to put any faith in the statements of the fishermen regarding the sea-lion depredations. The period covered by the researches of the commission has been a limited one but even in this limited period sufficient

evidence was obtained to prove that during a certain time of the year at least, food fish are eaten in large quantities by grey sea-lions. As in this instance the statements of the fishermen are definitely corroborated, there is evidently a fair basis for accepting other statements upon which there is general agreement, provided always that allowance must be made for a bias, natural to those interested in this as in any other question. It is on account of this bias that the evidence from independent witnesses is always desirable. Taking that into consideration, it is recommended that the commission should continue to study the life-history of the sea-lion, particularly during the breeding season, which corresponds to the time of the big run of sockeye at Rivers inlet. This should be accomplished with comparative ease but the habits during the remainder of the year cannot be so readily ascertained as in such investigation many difficulties will have to be overcome.

The amount of food required just after the pupping season cannot be considered as an index for the rest of the year. That taken by the sea-lions in Barkley sound in November and December would be much nearer the average. The results of feeding in captivity do not help much as opinions differ so markedly. Thus, as previously quoted, Hornaday states that 12 pounds a day or less is sufficient food for an adult male sea-lion, while Scammon says, the keeper at Woodward's Gardens, San Francisco, informed him that he fed a male and a female sea-lion, regularly, every day, fifty pounds of fresh fish. [1] In any case, the amount of food required by a sea-lion in captivity, where its movements are necessarily much restricted, might be very different to the amount required by one during the active life out in the sea, where, in many instances, the food is so plentiful that there is great temptation to eat more than actual necessity calls for.

The presence of dogfish remains in the stomach of a sea-lion caught in Barkley sound opens up a large question that should be investigated, particularly in view of the statement that the dogfish cease to bother the herring nets as soon as the sea-lions appear in the neighbourhood. While a definite comparison of the damage done to the herring fishery by the dogfish and the sea-lion is impossible, this at least can be said: while it does not pay to fish for herring when the dogfish interfere and the sea-lions are absent, it does pay to do so when the reverse is the case. If the disappearance of the dogfish is in any sense due to the presence of the sea-lion, the sooner the matter is investigated the better.

Although at the present time no other species is so much a pest as the dogfish, there are other undesirable species, and while the commission has no definite information as to the relation of any of these to the sea-lion, the possibility of the sea-lion's maintaining equilibrium in such cases is worthy of consideration.

While the commissioners recommend that sea-lions should be driven away or greatly reduced in numbers where it is evident that they are doing appreciable damage, they are not satisfied that there is any necessity for decreasing the numbers at other rookeries, except after some organized plan by which the pups could be free from injury, as in the case mentioned off the Oregon coast, in order that the industrial value of the sea-lions should be conserved, and more particularly in view of the possible friendly offices of the sea-lion that suggest further inquiry. Even in the case where it is considered necessary to diminish the number of sea-lions materially, the monetary value of the hide and carcass should be taken into consideration in any plan adopted.

CHARLES F. NEWCOMBE.
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C. McLEAN FRASER.

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[1] Scammon, C. M. Marine Mammals of the Northwestern Coast, 1874, page 135.

PART II.

REPORT AND CONCLUSIONS OF THE SEA-LION INVESTIGATION, 1916.

In order to ascertain the effect upon the sea-lion population of the bounty of $2 per head which was placed upon them early in the year 1915, and the desirability or otherwise of continuing it, the commission appointed by the Biological Board of Canada considered it advisable: (1) to procure the number of individuals killed in order to obtain the bounty, (2) to visit the rookeries in order to make an estimate of the number of sea-lions still remaining in the province (3) to visit all localities from which complaints had been sent of depredations by these animals, and (4) to investigate, as far as possible, the nature of the food of the sea-lions, as grave doubts had been expressed by well-known men of science as to whether food fish formed any part of their diet, some authorities even stating that their principal food consisted of animals which are enemies of fish used by man.

The lateness of the season when the commissioners were first able to commence their labours and the unsuitability of the valuable government vessel for approaching the rookeries placed at their disposal, prevented them from completing the programme thus sketched. The number of sea-lions killed was obtained with approximate accuracy; a great deal of information was procured from the various fishing stations as to the damage done by them during the fishing season and a beginning was made in the line of inquiry as to whether sea-lions do or do not eat food fish at one of the points at which complaint was made of their interference and destructive habits.

The rookeries, however, were not adequately examined, nor had the commissioners any opportunity of personally investigating the food question at Rivers inlet, one of the most important salmon fisheries on the coast and one from which the most urgent complaints of damage had emanated, and also that one in the neighbourhood of which by far the greatest number of sea-lions, pups and adults, had been slaughtered early in 1915.

It was therefore pointed out by the commissioners in their report for 1915 that it was their opinion that, with the object of completing the task originally proposed by them, their work should be resumed in 1916 early enough to be on Rivers inlet fishing ground during part of the salmon season and also in time to visit the rookeries when the sea-lions were assembled to bear their young, in order to be able to make as accurate an estimate of their numbers as possible.

The lack of facilities for communication with Rivers inlet made it difficult to decide on the most suitable time to visit this locality. The regular mail service and the telegraph and telephone communication made it an easy matter to get data as to conditions at Barkley sound, but at Rivers inlet telegraph and telephone communication is lacking and mail arrives but once a week.

From reports already received the commission was led to believe that sea-lion depredation occurred both before and after the pupping season in early June. Since it was desirable to get as full information as possible as to the numbers of sea-lions at the different rookeries, it seemed possible that this could be obtained during the trip in which the Rivers inlet question was to be considered.

For the twofold purpose especially, a 45-foot motor launch, the *Emoh*, was chartered, with Captain Massey commanding. Leaving Vancouver on June 21 and Departure Bay the following morning, a start was made for Rivers inlet, and

Wadhams was reached on June 24. On this part of the trip, as well as throughout the remainder of it, advantage was taken of every opportunity to confirm or add to the information already received.

Contrary to expectations, there was no sign of any sea-lions in the inlet and no word of any being seen, singly or in herds, as they had been reported early in the season in other years. Since, therefore, there was no immediate prospect of carrying on personal investigation in Rivers inlet, the commission proceeded to make a survey of the various rookeries.

17. SURVEY OF THE ROOKERIES.

I. The Sea Otter Group.

In the first place attention was directed to the rookery on the Sea Otter group of islands, near the entrance to Rivers inlet. Manager Inrig offered to send out a Wadhams Cannery boat with its crew and others armed with rifles to shoot some sea-lions for inspection. The offer was accepted, and on June 25 the rookeries were visited.

On Pearl rocks, the first of the group to be visited (see fig. 2), there were about 250 sea-lions, about 50 of them being pups. As the sea was smooth, a landing was made from a row-boat, on the largest of the rocks, and a female, 7 feet 1 inch long, which had been shot, was opened and examined, but the stomach was empty. Here, as on the other rocks in this group, the pups were very young, some of them newly born, and none of them yet able to take to the water or to swim properly if they did get in.

Watch rock (see fig. 3), was next visited, but on this there were three adults. Two of these were shot and examined. They were both small males, one of them 7 feet 6 inches in length (see fig. 5) and the other 8 feet 1 inch. The stomachs were empty.

Finally the Virgin group was visited. This group consists of three larger rocky islands and other smaller ones. There were lions on all, a total number of at least 2,500, of which nearly 1,000 were pups. One male, 10 feet 4 inches long (see fig. 13), was examined, with the same result as in the other cases.

Evidently it was no use trying to learn what the sea-lion takes as food by examining the stomachs of those killed on the rookeries, and hence the members of the commission wished for no further slaughter. The boat crew were not satisfied with this, however, and many more were made to suffer. The adults all took to the water at the sound of the first volley if they had not already done so on the near approach of the boat, but they come to the surface at short intervals, rising until the head, neck and shoulders are visible, at which time they offer a target to the marksmen. The young pups are very helpless, so that they may easily be approached and many of these were clubbed to death. (It was in this way that most of them were killed for bounty the previous year.) Several photographs of pup groups were obtained on both Pearl and Virgin rocks (see figs. 6-12).

II. The East Haycocks.

On the following day, June 26, the rookeries to the northwest of Vancouver island, on what is sometimes known as the cape Scott group of islands, were visited. On the way from Rivers inlet, sea-lions were again seen on the islands of the Sea Otter group, but no attempt was made to get near enough to make an estimate of the number. Channel rock to the southward of Pearl rocks was showing slightly above water and on it there were about twenty-five sea-lions.

In the cape Scott group, the West Haycocks were first visited but no sea-lions were visible. The East Haycocks, however, presented the most wonderful sight of

the whole trip. For a considerable distance above the water's edge, the rocks everywhere were lined with sea-lions. The lowest estimate made as to the number was 6,000. The pups here were larger and hence, in such a number, it was difficult to distinguish them from the yearlings and small females. For that reason the number of pups could not be approximated. As it was pouring rain unfortunately photography was out of the question.

No rookeries have been reported from the larger islands, Lanz and Cox, therefore, although the shores were scanned with glasses from a distance, no closer examination was made. Triangle island, which formerly was the base for a large rookery, no longer supports one. The island was not visited but by means of wireless communication the commission was assured that no breeding took place there in 1916.

In the open ocean for miles around Haycocks, sea-lions were seen, singly or in small groups, the last of these for the day about 14 miles away in the direction of Quatsino sound.

III. Solander Island.

The rookery at Solander island, off cape Coop, was examined the following day, June 27. The day was fine and the sea smooth. The *Emoh* was left in the offing, while two members of the commission in the boat's dinghy, rowed over to the rookery in the hope that some photographs could be obtained before there would be much commotion among the members of the herd. Such hopes were vain for so timid were these huge beasts that even the approach of this small boat struck them with terror and they began to tumble off into the water, consequently, in order to show any large portion of the number, long range photographs had to be taken (see figs. 16, 17). Three or four of the large bulls remained to be seen at shorter range, swaying from side to side and uttering most deafening roars. Some of their most faithful consorts remained with them almost to the last. One in particular seemed very loath to go (see fig. 21). He was probably the largest of the herd, and one of the largest seen at any of the rookeries, but he, too, finally took the plunge. His total length must have been over 12 feet and his weight over a ton. (Dr. Newcombe in his sea-lion report for 1913, gives the actual weight of a 12-foot sea-lion, brought into Alert bay, April 26, 1913, as 2,240 pounds.)

In the water the animals seem to have less fear, and when a score of them came up at the same time, near together (see fig. 23), and in close proximity to the small boat, to give their deep roar in unison, one felt that it was as well that they did not realize the extent of their powers.

This rookery was not a large one, so that the number, little in excess of 500, could be fairly accurately counted. Here again the pups were large enough to take to the water, and they were among the first to do so; hence the relative number could not be definitely estimated.

On June 28, while returning from Sea Otter cove to Rivers inlet, sea-lions were seen at cape Russell and other points between this and cape Scott.

IV. Cape St. James.

There remained one large rookery, that on the rocks off cape St. James, at the southern extremity of the Queen Charlotte islands, and a start was made for this on June 29. In the neighbourhood of Estevan island, engine trouble developed to such extent that it was necessary to go to Prince Rupert for repairs. This made a delay of some days.

On July 9, Butterworth rocks, to the northwest of Stephens island, were visited, as this is a well-known hauling-out place, but not a rookery. Two sea-lions were seen.

These were 150 miles from the nearest known rookery. They disappeared into the water while the boat was still at long range, but they appeared to be of good size. They could hardly be breeding adults so far away from a rookery, and there were no pups on the rocks. They were probably bachelor males, such as were seen and examined on Watch rock in the Sea Otter group.

Hecate strait was crossed on July 11, and cape St. James reached on July 13. Here again the day was fine and the sea smooth, with the exception of a certain amount of swell. Thus near approach was possible, and some photographs were obtained (see figs. 30-33), but no attempt was made to land. There were only about 1,000 sea-lions on the rocks, and the pups could not readily be distinguished from the other members of the herd. Individuals in the water were seen as far away as Scudder point, 25 miles distant from the rookery.

On the return, Rivers inlet was reached on July 17.

18. A COMPARISON OF THE ENUMERATIONS OF 1913 AND 1914.

While the rookeries are still under consideration, it is well to compare the enumeration here made with that made by Dr. C. F. Newcombe and W. A. Newcombe in 1913[1]. A table of comparison will serve as a basis for bringing out special points.

Rookery.	1913.		1916.	
	Date.	Number.	Date.	Number.
Cape St. James	June 12, 13	2,000	July 13	1,000
Sea Otter group—				
Pearl rocks	June 21, 22	1,350	June 25	250
Watch rocks	June 22	112	June 25	3
Virgin rocks	Aug. 28, 29, Sept. 2	2,300	June 25	2,500
Cape Scott group—				
Triangle island	July 15, 19	300	None breeding.	
East Haycocks	Aug. 17, 25	3,200	June 26	6,000
Solander island	July 29	None seen.	June 27	500

To this should possibly be added about thirty-five, which were seen by the commissioners off Hope island, September 3 and 4, 1915, where it may be, as the Nawhitti Indians aver, there is a small rookery. This was not visited either in 1913 or 1916.

There is little difference in the total estimate in the two cases, but a comparison of the individual rookeries bears out the statement made in the earlier report that to get the extent of the whole sea lion population, the number seen on the rookeries must be increased by an unknown number representing those in the water at the same time.

Taking the cape St. James rookery in the first place, if the whole 1913 herd was on the rocks when Dr. Newcombe made the enumeration and the whole 1916 herd was on the rock when the commissioners made the enumeration, there is no accounting for the reduction of the numbers as no raids were made on the rookery for the bounty in 1915 and very few were killed that could have belonged to the herd. The discrepancy is even greater than would appear from the above figures. The 1913 enumeration was made on June 12 and 13, when, as was stated in the report, but few pups had been born. In 1916 the enumeration was made a month later, when the pups of the year would not only all be born, but all able to take to the water. To make a more correct

[1] Provincial Fisheries Department's Report, British Columbia, 1913, pp. R131-R145, with 16 plates.

comparison it would be necessary to add about 500 to the 1913 number for the pups that were born in that year. Unless in the meantime there was an epidemic, or an extensive migration took place, neither of which is probable, the number on the rocks on July 13, 1916, did not by any means represent the whole herd. The fact that several were seen at various points even up to 25 miles from the rookery, bears this out. It is even probable that the two bachelor males (?) seen on Butterworth rocks belonged to this herd.

In this connection mention should be made of a conversation which the commissioners had at Claxton on July 15, with a Haida Indian, Timothy Tait, belonging to the Ninstints tribe, who is recognized by the Haida as the principal owner of the cape St. James rookery. He said that he didn't think the placing of the new lighthouse on the island of cape St. James had made any difference to the rookery, to which, as usual, he had paid several visits during the year (he had killed a number of sea-lions for food). He said he and his people found scattering pups at all times of the year, although the months of June and July were the most productive.

Coming next to the Sea Otter group, the only exact comparison of the two years can be made in the case of the Pearl rocks and Watch rock, since the time of the year almost exactly coincides. The large reduction shown in 1916 was to be expected from the number of onslaughts made on this portion of the rookery in the interval. Watch rock, which was a breeding place in 1913, evidently is one no longer. The portion of the rookery on Virgin rocks shows no material difference. Apparently the number killed has not materially decreased the size of the herd, unless, since the 1913 count was made over two months later in the year, it is quite possible a smaller percentage of the whole number was on the rocks.

In the spring of 1892, when J. M. Macoun, C.M.G., was acting on the Behring Sea Commission to make an enumeration of the fur seals, he visited these rocks and some notes in his diary, which he kindly put at the disposal of the commission, helps out in this comparison. On May 12, writing of the Virgin group, he says: "The largest island was then approached, and, as the sea-lions, by which it was covered, did not take alarm, a careful estimate was made of their numbers. Making allowance for all possible kinds of error, I can safely say, there were 1,500 on the one island, and more than 2,000 in the group." As this estimate was made on May 12, no pups of the year could have been counted. Hence the number, over 2,000, must be compared with the number apart from the pups, estimated at 1,500, in 1916. If this indicates anything, it is that, instead of a natural increase, which should be considerable in fourteen years, there has been a decided decrease here as on Pearl rocks. The difference of the attitude of the sea-lion towards mankind is striking. After seeing so many exhibitions of timidity in 1916, it is hard for the commissioners to realize that, not so very long since, the sea-lion did not take alarm at the approach of a boat, even at a time distant from the pupping season.

In the cape Scott group, the reduction in number on Triangle island, noted in 1913, has continued to the ultimate conclusion, as now no lions breed on the island. At the East Haycocks, the figures would indicate a great increase in number during the three years, when, as a matter of fact, there should have been a great decrease, since 2,290, from which the muzzles were taken, were killed, besides many that were not retrieved. During the summer of 1913, Mr. Grinnell and his men hunted the sea-lions on and around the Haycocks, until they had secured 500 hides. The surprise, therefore, is not that W. A. Newcombe did not see more than he did when he visited this rookery late in August, but that he saw as many as he did, after so much hunting. The large number seen on the rocks in 1916 did not represent the whole herd, since, as has been stated, numerous lions were seen in the water and on the rocks from cape Russell to cape Scott.

Considering, finally, the Solander island rookery, it will be noted that Dr. Newcombe saw none when passing on July 20, and that others passing near the same

time, notably Captains Gillam and Troup, who took special notice, at Dr. Newcombe's request, saw no sign of any, hence it was supposed that it was not a breeding place. Since on June 27 the pups were large enough to take to the water, they are able evidently to feed for themselvs by July 20, and the whole herd was away from the rookery. The majority of them must have been away even on June 27, as there were not nearly so many on the rocks as there were on September 14, 1915, when it was estimated that there were upwards of 1,000 visible. At that time the lions were present both on Solander island proper and the small outlying rock (see fig. 15), while on June 27 they were entirely confined to the outlying rock.

The number that haunt Barkley sound cannot well be counted here. If they are from a British Columbia rookery, they have probably been counted in with the others, and if, which is more probable, they come from the Jagged islet rookery, off the Washington coast, they cannot properly find a place in this enumeration.

Summing up the whole matter, although the enumeration in 1913 as well as that in 1916 was as well done as it could be, by making a single visit or few visits to each rookery, there are little data for comparison of the relative numbers in the two years. The estimate on the rookeries is slightly higher in 1916 than in 1913, but that is largely because in the majority of cases the visit was made at a more opportune time. It would not be legitimate to draw the conclusion from the figures that the number of sea-lions was greater in 1916 than in 1913, especially in the face of the fact that 8,000 animals had been killed in the intervening period. The only instance where a direct comparison could be made, viz., at Pearl and Watch rocks, there was evidence of a decided diminution. While in round numbers 10,000 fairly well represents these seen on the rocks at the rookeries, there is a large number besides these, possibly even as great a number or greater, scattered over a wide area along the whole coast.

19. THE RIVERS INLET SITUATION.

Having finished the examination of the rookeries, the whole attention of the commission was turned to the Rivers inlet situation. The return from Queen Charlotte islands on July 17 should have been at the height of the season for sockeye—the special tit-bit for the sea lion—during which time the depredations are most serious. Judging from the number reported in previous years, the commission concluded that there should be no difficulty in getting several sea-lions, shot right in the fishing area, that the stomachs might be examined at a time there would be every chance of seeing the quantity and nature of the food before it would be digested to any extent.

From the outset, however, the prospects were none too promising. The season was wet and backward, the fish were running low, so that catches were very small. Although sea-lions were reported in the inlet, they were much less numerous than in preceding years, but torn nets and mutilated fish were shown to indicate that they still were doing damage.

At several canneries along the inlet there were Indians who had hunted fur seals. If any of these could be obtained to shoot and spear the sea-lions, the best results could be expected. Because of the poor season, every available man was required to fish, and it proved no easy matter to get any of them to undertake sea-lion hunting. After some delay, a Sitka Indian, Louis, agreed to try his luck, but no one with experience could be obtained to go with him. The best that could be done was to hire an Indian boy, Jimmie, as boat puller. These two were supplied with a boat from one of the canneries, a rifle, ammunition, and a spear and taken down to where some of the outermost nets in the inlet were drifting, as it was here that the most damage was reported. They were out with the nets on Wednesday and Thursday nights, July 19 and 20 (the lions did not bother in the daytime), while the *Emoh* was moored at the Goose Bay fishing camp near by. Neither sound nor sight of sea-lion was noticed on either occasion, although the fishermen still reported their presence.

The following detailed reports were obtained from the fishermen in the neighbourhood on Thursday morning:—

Boat 1397 reported seeing two sea-lions near the nets the previous night.

Boat 4867 reported being bothered the previous night by the sea-lions, but not as much as the night before.

Boat 4901 reported that sea-lions had torn the net the previous night.

Boat 4876 reported that sea-lions had been seen all afternoon the day before down by the point.

Boat 1381, manned by a Jap, reported no trouble.

Boat 1405, also manned by a Jap, reported that sea-lions were on the net the night before between 8 and 9 o'clock.

Boat 4791 reported no trouble the previous night, but some the night before.

Boat 4588 reported that fish had been taken from the net and eaten about 11 o'clock the previous night. Claimed by fisherman that he had lost 50 fish in a week, shown by the heads and tails left in the net.

Boat 1398, manned by a Jap, reported that he had seen sea-lions in the net about 10 o'clock in the morning.

Boat 4915, from the Good Hope cannery, reported disturbance by sea-lions in the net the previous night.

An independent boat reported that he had seen sea-lions in the inlet at 4 o'clock the previous afternoon.

Boat 4870, a Good Hope cannery boat, reported having seen sea-lions during the night.

Boat 4844 reported having noticed sea-lions in the inlet the previous night at 9 o'clock.

Boat 1416 reported that fish had been eaten by sea-lions on the net at 8 o'clock the previous night.

Boat 1153, manned by a Jap, reported that he had not been bothered with sea-lions.

Boat 1394, manned by a Jap, reported having seen sea-lions in the fishing area at 11 o'clock the previous night.

After the negative results of Wednesday and Thursday nights, Manager Inrig and Net Foreman Anderson (it may be mentioned here that cannery managers and men, especially those at Wadhams where the commission made its headquarters, gave every assistance in the investigation consistent with the serious demands on their time occasioned by their own interests) intimated that some of the white fishermen would be willing to give assistance. Accordingly, several of them were supplied with ammunition and a substantial reward was offered for each sea-lion brought in. Louis went out with one of these fishermen to be right at the net as Jimmie in the meantime had been discarded. Friday night proved no better than the others, although some torn nets and mutilated fish were still shown as evidence of the sea-lions' presence.

The weekly close season lasts from 6 a.m. on Saturday to 6 p.m. Sunday. The net foreman offered the use of two nets for Saturday night if permission could be obtained from Fisheries Overseer Saugstad, the idea being that if two nets, and only two, were put out Saturday evening, all the inducements for the sea-lions would be centred around these nets. Mr. Saugstad readily granted permission and arrangements were made to carry the plan into effect. Two men were assigned to each boat. S. Simonsen of Sea Otter cove, V.I., went with Louis in the one boat, while G. Bjerregard, of Holberg, V.I., and J. C. Holm, of Campbell river, V.I., manned the other. From long experience these men were thoroughly acquainted with fishing

conditions in the outer part of the inlet. The commissioners, as on previous occasions, remained near by in Goose bay. Early in the morning the men were picked up but no sea-lions had been shot and there was little evidence of their presence except the remains of three sockeye and one humpback that were found in the nets. A photograph was taken of these remains (se fig. 34.) It is interesting and instructive to compare this photograph with one taken at the Canadian Fish and Cold Storage plant at Prince Rupert, September 8, 1915, which shows the way in which salmon are mutilated by hair seals (see fig. 35.)

20. LITTLE EVIDENCE OF SERIOUS DAMAGE IN 1916.

After a week of negative results there was no encouragement to stay longer and the commission prepared to depart on the following morning. As the fishermen would all be fishing again on Sunday night, they were encouraged to make a final effort to get sea-lions while the commissioners were still in the neighbourhood. The *Emoh* anchored in Goose bay for the night, and in the morning (July 24), since there were no results reported, a start was made for home at 4.30. As the fishermen were still confident that sea-lions could be captured in the inlet, they were assured that the offer of reward would hold good until the end of the season, if the stomachs were sent to the Biological station for examination. No claim has yet been made for such reward.

21. PROBABLE AMOUNT OF INJURY DONE BY THE SEA-LION.

It will be seen from the above account that the commission spared no pains to get concrete evidence on the situation at Rivers inlet. If a week of such endeavour at the height of the season could produce no positive results, there was no hope that a whole season's residence there would do so. Such being the case, the commission feels justified in stating that, as far as the 1916 season was concerned, the sea-lions were not a very decided menace to the fishing in the inlet. The *Emoh* travelled several miles up and down the inlet every day during the sojourn there, and only on one occasion was there seen a trace of a sea-lion, and at that time only one was seen. The majority of the men that fished in the outer part of the inlet were questioned, none of whom reported having seen more than four or five. The sea-lion is undoubtedly to blame for some torn nets and mutilated fish, but that he alone is to blame is open to question. On account of his bad reputation, all the blame is put on him whether he deserves it or not. It might be mentioned that nets are commonly torn at other fish centres where the men scarcely know what a sea-lion looks like. All the fishermen agree in declaring that the damage in 1916 was much less than in the previous years. If any further evidence is needed to show that the commission is more than justified in making this stand, it is supplied by a letter to the secretary from Mr. Frank Inrig, dated November 19, after the close of the fishing season. It reads as follows:—

To the Secretary of the Sea-Lion Commission,
Room 929 Birks Building, Vancouver, B.C.

DEAR SIR,—As manager of the British Columbia Packers' Canneries, Wadhams and Brunswick, at Rivers inlet, I can speak with knowledge of the depredations of the sea-lions in former years to the commercial fisheries at Rivers inlet. Up to two years ago these depredations were great, and in terms of money, costly to the canneries.

But the expenditure of a few thousand dollars on bounties by the Federal Government, two years ago, resulted in many sea-lions, both young and old,

being killed at and on the rookeries in the Pacific, and besides that a thorough scare being thrown into all the sea-lions frequenting the waters adjacent to Rivers inlet. The sea-lions, always timid, became exceptionally timorous in the presence of man, and shunned rather than sought the fishing areas. This to my mind was due to the hunting of sea-lions induced by the offer of a bounty.

In the year 1916 the sea-lions were not excessively harmful. They did not bother the fishing operations at Rivers inlet to any great degree, and not at all as they did three years ago. This I attribute to the effect of the hunting under the bounty system, and also to the fact that before the season opened for fishing the sea-lions on the Sea Otter group of rookeries were pretty thoroughly scared by being shot at and in some cases killed by fishermen at Rivers inlet. I think they have lost their voraciousness and courage to appear where man is and where fishing operations are being carried on at Rivers inlet.

Now I do not think the sea-lions should be killed off as long as they remain as quiet as they did this year, for their hides may still be made use of for commercial purposes and their carcasses turned into hen food or fertilizer, but I do think that the Federal Government, through the Fisheries Overseer at Rivers inlet, might spend two hundred dollars a year on ammunition to be served out to the fishermen for them to make a scare raid on the Sea Otter group of rookeries every year before the salmon fishing begins, in order to terrorize the sea-lions and make them fearful of man. This would keep them away from the fishing operations throughout the season and protect the fish and the gear of the fishermen. Don't kill off the sea-lions, but strike terror into them.

If this communication is of any use to you, you are at liberty to do with it as you wish.

Yours faithfully,

FRANK INRIG.

VANCOUVER, B.C.,
November 19, 1916.

There are still large numbers of sea-lions along the British Columbia coast. On the rookeries alone over 10,000 were seen in June and July, 1916. The rookery estimate is not sufficiently accurate as an index of the whole number to show the reduction that took place by the slaughter of 8,000 sea-lions in 1914-15 and to some extent in 1913, except in the case of some of the rocks of the Sea Otter group, where extensive diminution was indicated.

The menace to the fishing industry in Rivers inlet, so much complained of in previous years, had largely disappeared in 1916.

The Steller sea-lion undoubtedly eats large quantities of food fishes at certain times of the year, but for the remainder of the year there is little or no evidence as to what he does eat. Since it has been shown that fish not used as food as well as squid and devil fish are eaten, he cannot at all times be the epicure that some people would have us believe. Although he requires animal food, it is probable that he will take any kind available in quantity sufficient to satisfy his hunger. It is even possible that in helping to keep down other injurious species he does more good than harm to the fishing industry, provided he can be kept away from the nets or other fishing gear. Reference has been made to the influence the sea-lion may have on the dogfish question and the dogfish is not the only carnivorous species that is taken as food.

22. SUGGESTED CONTROL OF DESTRUCTION OF SEA-LIONS.

The economic side of the question has been discussed and it is not necessary to refer to it again except to mention two points. The first is that the price of leather is rapidly going up, thus adding force to the argument as to the value of sea-lion skins. The second is with reference to the sea-lion carcass. It has been truly said that the flesh should make good fertilizer and poultry food, but it must be remembered that up to the present, plants for producing marine animal fertilizer on this coast have not been especially noted for their financial successes. Sea-lion carcasses cannot be taken to any of the fertilizer plants now in existence and made use of at a profit. With the processes now in use, it would not pay to erect a fertilizer plant to make use of fish offal at Rivers inlet or any other fishing centre where the fishing season is so short. No line of economic research in connection with the fishing industry on this coast offers a more promising field than that to do with the elimination of waste or rather the transmutation of waste products to products of commercial value at a cost that will ensure a reasonable profit on the outlay. When cheaper methods of producing fertilizer and poultry food have been worked out, the sea-lion carcass may become an important factor.

The commissioners have no hesitation in stating that they can see no valid reason at present at any rate for adopting any plan looking toward total extermination of the Steller sea-lion. Even when its depredations were most serious it has been shown that these can be reduced to a negligible quantity in a comparatively short time. Since that is so, it should not be a difficult matter to keep the depredation at a minimum. It may be well that, as Manager Inrig has suggested, this could be done by spending $200 for ammunition each year to scare them away and terrorize them. If it could be done at Rivers inlet it should be done equally well at Barkley sound, possibly better since the lions come in there apparently in a single group about the first of November. If this were done it should be under the control of the Federal Department of Fisheries, as Mr. Inrig suggests. If the scare is not sufficient, it might be advisable to materially reduce the numbers of sea-lions at the rookery responsible for the depredation, when the menace became threatening. In either case the operation should be so controlled that the greatest commercial value could be obtained. Indiscriminate and promiscuous killing should not be tolerated.

While the number of sea-lions is as great as it is at present, it might be legitimate to allow the killing of a certain number each year as in the case of all other species of commercial value, provided that not more than the number which would represent the annual increase were taken, under conditions that would ensure conservation.

CHARLES F. NEWCOMBE,

WM. HAMAR GREENWOOD,

C. McLEAN FRASER.

23. APPENDIX A.

I. FORMAL QUESTIONS SUBMITTED TO SALMON CANNERS AND OTHERS.

SEA-LION COMMISSION.

(Appointed under Authority Biological Board of Canada.)

1. Are Sea-Lions injurious to the Fisheries of British Columbia?..................
2. Have your own fishing operations ever been injured or interfered with by them?...
3. Please state the nature of such damage this year and the estimated loss:

   Gear .. .. $..........
   Mutilated fish .. ..
   Diverted run of fish .. ..
4. Other years?..
5. Is the lessened run of fish (if any) attributable to Sea-Lions?...................
6. Has the Herring Fishery been interfered with this year by Sea-Lions?...........
7. Have you noticed any steady increase year by year to the amount of injury caused by Sea-Lions?..
8. Are Sea-Lions of any commercial value?...............................
9. Do they assist your fisheries in any way?................................

[*Methods of dealing with Sea-Lions if considered to be injurious to the Fisheries of B.C.*]

1. Do you recommend complete extermination or merely a reduction in numbers?....
2. Could your company deal with this question in your neighbourhood without Government aid?...
3. If not, in what manner could the Government most effectually aid you?.........

   [A] By employing hunters under Government supervision?..............
   [B] By offering a bounty open to all willing to hunt?..................
   [C] By providing money or ammunition to be expended under the control of the fishing companies?...
4. Can you give information as to the existence of Rookeries or other places frequented by Sea-Lions in your neighbourhood?..............................
5. What is the best time for killing them?.....................................
6. What is the best method?..
7. What is the best evidence on which to pay the bounty?....................... (At present the muzzle is taken as proof.)
8. Should the bounty be paid for pups, or adults, or both?.......................
9. What has been the effect of the bounty for killing Sea-Lions upon this year's fishing?...
10. Have you any remarks or suggestions to make not covered by the above list of questions?...
11. Have you examined the contents of Sea-Lion stomachs?........................

II. FORMAL LETTER SENT BY THE SECRETARY OF THE COMMISSION TO CANNERS AND OTHERS.

SEA-LION COMMISSION.

To the Manager,

Dear Sir,—On behalf of the Sea-Lion Commission appointed under the authority of the Biological Board of Canada, we invite your cordial assistance in getting information and opinions regarding the alleged depredations of these animals.

It has been stated that sea-lions destroy fish and fishing gear and interfere with the free prosecution of fishing operations by means of seine nets and other appliances.

It also has been suggested that the sea-lions be exterminated or so thoroughly attacked to death by man as to frighten them away from their depredatory raids, and that this be encouraged by giving a bounty of two dollars ($2) a sea-lion, such bounty to be paid on presentation of the muzzle of the animal as voucher for its extinction.

We will be glad if you will answer the questions set out in the enclosed form to the best of your knowledge and belief, and add any observations you may think fit. It has been suggested that the canneries, where any depredations from sea-lions occur, might be left to handle the problem themselves without any idea of government bounty, on the assumption that fishermen attached to the canneries would protect their own interests.

Your speedy attention to the requests made on you in this letter and enclosed form will be appreciated and will assist the sea-lion commissioners in the preparation of their report on the whole question.

APPENDIX B.

NUMBER of Sea-Lions on which bounty has been paid in British Columbia for the fiscal year 1915-1916.

Name of Claimant.	Number Paid For.	Where Killed.	Amount of Bounty paid.
			$ cts.
Andrew Spalding	24	Banks island	48 00
Henry Rudland	1	Butterworth rocks	2 00
George Jones	1	Massett	2 00
J. W. Robinson	11	Price island	22 00
John Wootten	20	Calvert island	40 00
Henry Brown	12	Bonilla banks	24 00
Wm. Leighton	1	Tree Nob island	2 00
Peter Robinson	1	Stephens island	2 00
David Parnell	2	Butterworth rocks	4 00
George Allen	15	Virgin rocks	30 00
J. Wootten	342	Sea Otter group	684 00
Jas. Robinson	2	Aristazable island	4 00
J. Wootten	49	Sea Otter group	98 00
F. S. Carpenter	1	Price island	2 00
Henry Brown	2	Bonilla banks	4 00
A. Goodman	50	Virgin rocks	100 00
L. H. Hogan	97	" "	194 00
Geo. Allen	57	" "	114 00
D. McLennan	63	" "	126 00
J. Wootten	1,174	East Haycocks	2,348 00
Dan. McCloskey	153	Pearl and Virgin rocks	306 00
F. S. Carpenter	26	Price island	52 00
Spruce Marten	2	Seymour inlet	4 00
Lake Joe	51	Virgin rocks	102 00
Jacob White	82	Sea Otter group	164 00
Chief Schwish	1	Village island	2 00
James Rush	1	Ucluelet	2 00
Wm. Taylor	2	Otter point	4 00
Dan. Quital	1	Duncan bay	2 00
Jacob White	442	East Haycocks	884 00
Albert Thompson	180	Virgin rocks	360 00
Tom George	1	Smith's inlet	2 00
Benson Keatta	1	Ahousat	2 00
Wm. Fatty	1	Ahousat	2 00
Joe Hayes	1	Long Beach	2 00
Joe Williams	2	" "	4 00
Joe Martin	2	Cape Cod	4 00
Abram Jeffries	1	Thormanby island	2 00
Totals	2,875		5,750 00

EXPLANATION OF FIGURES.

1. Wadhams cannery, Rivers inlet. The *Emoh* is the white boat in the right foreground.

2. The largest of the Pearl rocks.

3. Watch rock.

4. The largest of the Virgin rocks after all the adult sea-lions had taken to the water.

5. Male sea-lion killed on Watch rock.

6-12. Groups of sea-lion pups on Pearl and Virgin rocks.

13. Male sea-lion killed on one of the Virgin rocks, and two pups.
(2-13 were taken June 25, 1916.)

14. A figure to show the position at Solander island relative to cape Cook.

15. Solander island.

16-18. The outlying rock at Solander island, taken as the sea-lions were leaving it.

19-22. Remnants of the herd, showing some of the largest males.

23. Sea-lions in the water at Solander island.
(14-23 were taken June 27, 1916.)

24. A figure to show the relative position of cape St. James island, on which the lighthouse is situated, to the main island, Kunghit. Four groups of rocks extend in a chain southward from cape St. James.

25. A figure to show the position of the first two groups of rocks relative to cape St. James island.

26. The first group of rocks south of cape St. James island.

27. The second group.

28. The third group.

29. The fourth and final rock. It was on the second and third of these groups that the sea-lions were seen in abundance.

30-33. Views of the sea-lion herd on the rocks at cape St. James.
(24-33 were taken July 9, 1916.)

34. The remains of three sockeye and one humpback (the largest piece being the humpback) taken from a net in Rivers inlet July 23, 1916, said to have been mutilated by sea-lions.

35. Remains of salmon taken from the nets near Prince Rupert, September 8, 1915, said to have been mutilated by hair seals.

36. Scow on which Dr. Newcombe and Mr. Patch examined sea-lions in December, 1915, near Kildonan cannery, Barkley sound.
(Photos 1-35 by C. M. Fraser, 36 by C. F. Newcombe.)

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17

Fig. 18.

Fig. 19.

Fig. 20.

Fig. 21.

Fig. 22.

Fig. 23.

Fig. 24.

Fig. 25.

Fig. 26.

Fig. 27.

Fig. 28.

Fig. 29.

Fig. 30.

Fig. 31.

Fig. 32.

Fig. 33.

Fig. 34.

Fig. 35.

Fig. 36.

II

LOBSTER INVESTIGATIONS AT LONG BEACH POND, N.S.

(A. P. KNIGHT, M.A., M.D., F.R.S.C., Professor of Animal Biology, Queen's University, Kingston, Ont.)

RECOMMENDATIONS.

1. That the rearing operations hitherto conducted by the Board at Long Beach pond be discontinued.

2. That the executive committee consider the advisability of securing from the Fisheries Branch of the Department of Naval Service full control over the operation of one of the present lobster hatcheries, in which to conduct a series of experiments on the rearing of lobster fry, using warm sea-water, as suggested by Professor Macallum.

3. That the executive committee confer with the department as to the best method of collecting statistics regarding the relative numbers of male and female lobsters trapped next season, and also the percentage of females carrying fertilized eggs.

4. That several more enclosures be built at a moderate cost, by either the Board or by the Fisheries Department at different points along the maritime coast, for the purpose of determining more definitely the percentage of commercial lobsters which extrude eggs in July and August.

ACKNOWLEDGMENTS.

Acknowledgment is due the Department of Naval Service for furnishing a plentiful supply of both berried and commercial lobsters for the purpose of carrying on the experiments described in the following report; also for placing at the disposal of the Board the services of Mr. Andrew Halkett. Mr. Halkett gave us every assistance. More particularly, he kept an accurate count of the lobsters received at the pond, allotted to the various enclosures, and returned to the sea.

The Board is also indebted to the department for moving the rearing plant from the southwest end of the pond, and placing it within the cement pound.

POUND AND POND.

In the following report the reader must distinguish carefully between the natural pond of some 5 acres, and the artificial pound of about three-fourths of an acre, enclosed by cement walls and forming the northeast part of the pond.

Fig. 1.—Long Beach Pond viewed from the northeast end. In the foreground can be seen first the mess-house; beyond this, the cement pound; further away is the larger part of the pond. In the distance can be seen the engine house and plant for rearing lobsters.

Last year, 1914, because of the excessive leakage of water from the pound, the Board approved of the location of an experimental rearing plant of four boxes at the southwest end of the pond, and my report upon the operations of that year has been already published.

LEAKAGE.

On December 18, 1914, the Board was notified that the leakage, which had persisted throughout the previous summer, had been stopped, and that there was at that date a depth of 6½ feet of water in the pound at low tide. During the winter of 1915, however, the leakage again developed and was again reported stopped on June 26, 1915. At this date there was said to be a depth of 5 feet 8 inches of water at low tide.

On my arrival, July 3, 1915, the pound was again leaking, not copiously, it is true, but sufficiently to show that in the course of a few days or weeks the rearing boxes, 4 feet in depth, would likely be resting in the mud. As a precaution, therefore, against possible injury to our larvæ, the boxes were reduced in depth to 2½ feet. On the assumption that there would be, as intimated, 6½ feet of water at low tide, a space of 4 feet would intervene between the bottom of our shallow boxes and the mud beneath.

At Wickford, R.I.—the original home of the plant—the depth of water below the boxes is 12 feet at low tide, excepting at one corner, where it is only 5½ feet. At Long Beach it was hoped that a depth of 4 feet might suffice to test the scheme. Last year at low tide there were only between 20 and 22 inches of water below our boxes; this year, after operating our plant for seventeen days, the boxes were resting in the mud, so great was the leakage.

Fig. 2 - West side of cement pound showing leakage of water. Over the ironrods at the upper left hand corner of the illustration can be seen the gearing of the rearing apparatus inside of the cement pound.

At the extreme low water of August 7, two of the boxes were resting 5 inches in the mud. Measurements at eleven different points around our apparatus gave the

following depths of water, 21 inches, 22, 17, 20, 17, 19, 19, 23, 24, 26, 24, or an average of 21 inches, in which to float our apparatus. It can scarcely be expected that an apparatus, which requires at least 10 feet of water in which to operate, can be made to operate successfully in a depth of 21 inches.

FIRST HATCHING.

Our first hatching began July 12, and in two days we had about 40,000 larvæ in the four boxes. While only an odd diatom could be found on the fry during the first day, large numbers were visible by the fifteenth. As the diatoms increased, the fry became "fuzzy" to the naked eye. Both last year and this the effect of the diatoms was largely, if not solely, mechanical. Feeding was interfered with, the animals became exhausted with the effort of swimming, sank to the bottom, and soon died.

The remarkable thing about this mortality was that last year it was caused by the diatom *Synedra investiens,* whereas this year it was caused by *Licmophora Lyngbyei.* Why the principal destructive organism should have been different in the two years is difficult to understand, unless it were due to the fact that in 1914 the sea-water reaching our boxes came through the sand, gravel, and mud of the sea-wall, whereas, in 1915 it came through an earthenware pipe from the open sea.

As soon as it became apparent that this season's fry were likely to share the same fate as those of last year, the contents of two of the boxes were transferred to St. Mary's bay, in order, if possible, to save their lives. Meanwhile the leakage steadily grew worse. On the 19th the average depth of water below the boxes was only 10 inches. As a result, good ventilation became impossible, because the water drawn in through the bottom windows gradually became muddy. It was resolved, therefore, not to use more than two boxes for rearing purposes for the remainder of the season. The other two were fitted up with shelters, or nests, for adult lobsters, so that more accurate observations could be made upon them than was possible in the compartments of the pound.

DETENTION DEVICES.

It should, perhaps, be explained that we employed five different devices, or enclosures, for impounding adults. The smallest was the crate, about 3 feet by 2 feet by 2 feet, which floated on the water, and could be used for temporary purposes only. The second was our rearing boxes, 10 feet by 10 feet by 2½ feet, with revolving paddles inside, so as to aerate the water, as described in the report of last year. The third was the compartment, 20 feet by 10 feet by the varying depth of the water at high and at low tide. The wooden slats of which it was constructed were only about 4½ feet high. As can be seen from the illustration, there were six of these compartments within the cement pound. The fourth enclosure was the pound, and the fifth, the pond, but these two latter were so large that is was impossible to use them for observation purposes. The compartments could be used for observation purposes only at low water. The real purpose of their construction was to serve as sub-divisions of the pound, in which lobsters could be kept for experimental and observational purposes.

FAILURE.

We had even worse luck this season than last. Of the 20,000 fry which we tried to rear in the two remaining boxes, beginning July 12, only twenty-one remained alive on the 30th of July, and they were all in the second stage of development. Not one had moulted a second time, and they had taken thirteen days before moulting even

once. Of the 20,000 to 22,000 fry which we tried to rear at a second trial, beginning August 2, only 146 were alive on August 17, and these also were all in the second stage.

In the August rearing the larvæ were shaded from the sunlight by heavy painted canvas screens lying close over the boxes; in July they were not. The effect of the shading appeared to be to reduce the first stage from thirteen days to nine days, and to lessen the number of diatoms; but the larvæ died just the same.

It is, of course, true that the warmer water in August (about one degree) may have had more to do with the shortening of the first stage than the exclusion of light. Indeed, the influence of direct sunlight upon larvæ is still an open question. To be sure, the fry, when left to themselves, swim straight into the light, but it does not follow that because they do so, the result to themselves is necessarily beneficial.

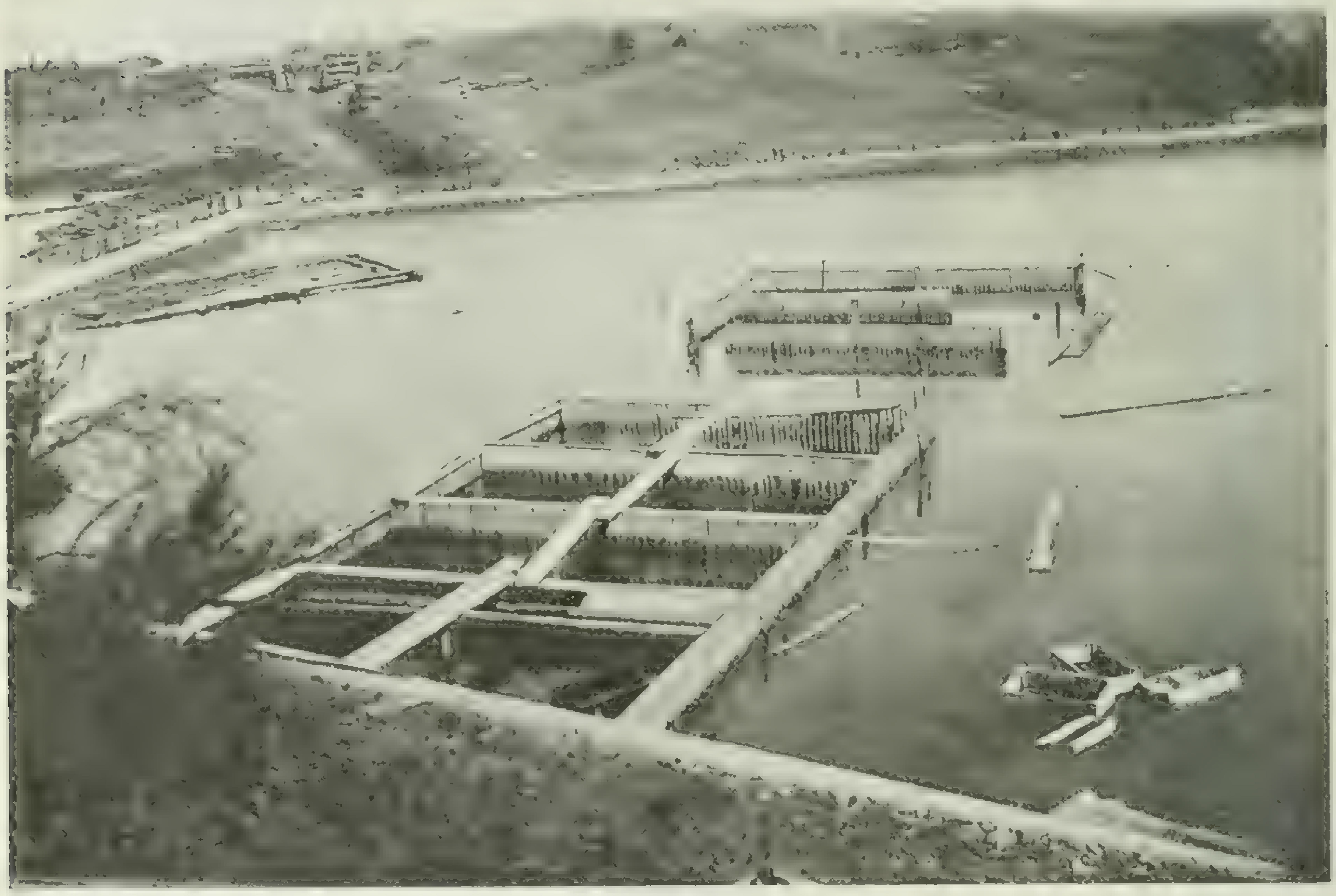

Fig. 3.—Showing the interior of the cement pound. The six latticed compartments are for retaining lobsters so that they can be studied at close range.

Leaving out for the present the influence of light, it may well be asked: "What favourable conditions exist at Wickford, that enable the operators there to raise 40 per cent of their fry to the crawling or fourth stage, which do not exist at Long Beach pond?" And the answer is: first, too slight a depth of water under our rearing boxes, thus favouring the entrance of mud and diatoms from the bottom; secondly, the presence in the water of an unusual number of diatoms not generally found in open sea-water;* thirdly, too low a temperature of water. While the temperature at Wickford varies during the rearing season from 68° to 75°, the mean average temperature at Long Beach this season was only 58·09° for July, and 58·9° for August. The two following tables give the daily temperatures at Long Beach for July and August, respectively:—

* Professor McClement's Report "Diatoms and Lobster Rearing"—Contributions to Canadian Biology, 1915-16. Supp. 6th Ann. Rep. Dept. Naval Service (Fisheries), Ottawa, 1917.

TEMPERATURES and kind of weather at Long Beach Pond, during the month of July, 1915.

Date.	Wind.	Temperature of Pound Water. Maximum.	Mean.	Minimum.	Temperature air outside.	Weather.
		°		°	°	
July 12...	SW.	.. ..	55·5	... .	not taken.	Foggy.
" 13 .	SW.	.. ..	58·0	....	"	Fair.
" 14...	calm.	Temp. in St. Mary's Bay 56.8.	56·0	....	"	Fair.
" 15 ..	SW.	....	59 8	.. ..	67·0	Foggy.
" 16. .	S.	....	57·3	... .	56·5	Foggy.
" 17. .	SW.	....	58·0	... .	59 8	Foggy and rainy.
" 18...	SW.	....	56·0	....	61·0	Foggy.
" 19 ..	SW.	..... .	58·0	.. ..	not taken.	Fair to rainy.
" 20...	SW.	....	56·0	.. . ..	55·7	Foggy.
" 21...	NE.	... .	58·5	....	not taken.	Raining.
" 22...	NE.	60 8	58·4	56·0	"	Cloudy.
" 23...	N.	62·0 62·0	60·2	57 60	63·0	Fair.
" 24. .	SW.	65·0 63·0	61 5	59·0 59·0	not taken.	Fair.
" 25...	E.	61.5 64·5	60·5	57·0 59·0	"	Fair.
" 26...	SW.	60 8 60 5	59·2	56·5 59·0	54·8	Foggy.
" 27...	SW.	59 0 57·0	55·8	58·0 55·0	58·0	Rainy and foggy.
" 28...	SW.	58 0 61·5	58·0	53·0 59·0	54·0	Foggy.
" 29...	SW.	61·0 58·5	57·5 ...	55·0 55·5	60 0	Fair.
" 30...	S.	57·5 61·5	58·5	55·0 60·0	64·0	Foggy.
" 31...	SE.	61·5	59 1	56·7	63·0	Foggy.
	Totals..		1161·8	. ...	716·8	

Mean average temperature of water = 58·09°. Mean average temperature of air = 59·7°.

TEMPERATURE and kind of weather at Long Beach Pond during the month of August, 1915.

Date.	Wind.	Temperature of Pound Water.			Temperature air outside.	Weather.
		Maximum.	Mean.	Minimum.		
		°	°	°	°	
Aug. 1	S. Faired 10 A.M.	62·3 65·5	60·5	57·0 57·3	78·0	Foggy.
" 2...	Calm and Cloudy	64·7 63 6	61·3	58·0 59·0	72·0	Foggy.
" 3...	N. Sun shining.	61·0 64·0	58·5	55·0 54·7	54·8	Fair.
" 4...	S.	61·0	56·5	52·0	59·8	Fair.
" 5...	NE.	61·0 61·5	58·1	55·0 55·0	58·8	Cloudy.
" 6...	NE.	61·0 66·0	60·0	56·5 56·5	59·8	Fair.
" 7...	S.	65·0 63·0	60·5	57·0 57·5	66·5	Fair.
" 8...	SW. changed to N.	63·0	60·0	57·0	58·5	Foggy.
" 9..	Calm.	64·0 59·5	59·3	57·0 57·0	62·0	Foggy.
" 10...	SW.	60·0 59·5	58·0	57·5 56·0	65·0	Foggy.
" 11...	NE.	60·5 64·7	59·9	57·5 57·0	60·0	Fair.
" 12...	SW.	63·0	60·0	57·0	59·0	Fair.
" 13...	S.	61·5	58·7	56·0	61·0	Foggy.
" 14...	S.	55·5 59·5	56·5	55·0 55·0	55·5	Foggy.
" 15...	NE.	59·5 60·0	58·0	56·5 56·0	64·0	Foggy.
" 16...	SW.	61·0 60·5	58·8	56·3 57·3	63·0	Foggy.
" 17...	SW.	60·0	57·7	55·5	62·0	Foggy.
	Totals....		1002·3	....	1059·7	

August Mean average temperature of water=58·9° Mean average temperature of air=62·3°
July Mean average temperature of water=58·09° Mean average temperature of air=59·7°.

On this subject the Rhode Island Commission remarks:—

> The temperature of the water is of paramount importance in order to obtain the best results. Although it is possible to rear lobsters with some success in cold water, the best results will be obtained with water at a temperature of 65° to 75° F. This higher temperature results in a more rapid development of the lobsters. This more rapid development results, first, in a reduction of the expenses of operating the plant, because of the less time required, and, second, in a greater proportion of fry reared to the fourth stage, because in the shorter time there is less chance for death from cannibalism, parasites and injury.

Prof. A. B. Macallum has suggested that, in order to overcome the handicap of cold water, we should use sea-water that has been heated to 68° or 70°. This appears to be a good suggestion, unless its adoption would increase to too great an extent the cost of operating our plant. At a moderate calculation, about 2 cubic feet of water per minute enters, and, of course, leaves each rearing box. To heat this quantity of

water from 58°, which is our average temperature, up to 70° will require the combustion of about 250 pounds of coal per day of twenty-four hours.

As the enlarged Wickford plant is composed of fifty-two boxes, the total consumption of coal for the rearing season of two months would amount to about 300 tons. Accordingly, to the regular expense of running a Wickford plant of fifty-two boxes, namely, wages of five men, gasoline, oil, food for the larvæ, wear and tear, there would have to be added in Canada the wages of an extra engineer and fireman, besides the cost of the 300 tons of coal.

WINTERING IN THE POUND.

Next to the leakage of water, the feature which attracted most attention at Long Beach during the early season of 1915 was the pitiable condition of the lobsters which had wintered in the pound. They were simply covered with growths of green, brown, and orange coloured algæ. The green measured from 1 to 3 inches in length, the brown from several inches to three feet, and the orange-coloured ones about one-quarter to one-half inch. These latter grew not alone on the body, but over the eyes, and rendered them blind, at least for the time being. Their gills varied in colour from grey to almost black, strongly suggesting that the function of these organs was impaired by a coating of the black mud in which they were compelled to live during the year.

The animals which had passed the winter in the pond were distinctly better. They were not so much infested with algæ, but the effects of their confinement became very apparent when they were compared with the commercial lobsters which were placed in the pond between May 10 and June 15. In the former the natural colours of the body were completely hidden by the grey mud and copious growth of weeds which they carried, whereas the latter showed the bright colours characteristic of the normal lobster. Moreover, the commercial ones were free from algal growths, and their gills exhibited the well-known flesh colour. The difference between pond and pound lobsters, on the one hand, and commercial lobsters, on the other, was comparable to the difference between the dirt and rags of a tramp and the cleanliness and dress of a gentleman.

CONFINEMENT.

The fundamental conditions for a healthy life are very much the same for lobsters as for other animals. They must have plenty of food, well-ventilated water, adequate exercise alternated with rest, and diffused sunlight. How many of these conditions can be said to be freely supplied to a lobster that passes all of its time in a crate, car, box, compartment of the pound, or even in the pound itself? One has but to think of the ill effects of confinement upon wild animals, or even upon domesticated animals, to realize how harmful it is. Human beings, whose occupation confines them much in factories, shops, or offices, and those who are confined in jails, asylums, or detention camps—all suffer more or less from their confinement. Is not the spread of tuberculosis among cattle largely due to their confinement in ill-ventilated stables? Do not zoological gardens also show instances of deterioration in health, due to the violation of the fundamental laws of biology? Lobsters can be no exception to the rule. When kept in confinement we cannot expect to find them in the same condition of health and vitality as when they live in the open sea. No wild animal flourishes so well in confinement as in the open. Liberty of movement is essential to health. It matters not whether lobsters are retained in small or large enclosures, or, for that matter, in the whole pond, the ill-effects upon the lobsters soon become apparent. In the case of the smaller crates and cars, the animals soon die. In the

larger compartments of the pound, or pond, the ill-effects may not become apparent for several months, but slowly and surely the lobsters' health and vitality are undermined and they finally succumb to the adverse conditions.

No doubt, by a long course of breeding and artificial selection, it might be possible, in the case of the lobster, just as in the case of our domesticated animals, to breed a stock that would be less sensitive to the ill-effects of confinement, but, until we have bred such a strain, the nearer we can make the conditions of confinement approximate to the conditions in which the animal lives in the sea, the lower will be the mortality.

MUDDY BOTTOM.

Next to the copious growth of weeds, blinding and encumbering the lobsters which had wintered at Long Beach, perhaps the next most unfavourable condition was the mud. There is, of course, mud and mud. Every lobster fisherman knows perfectly well that during winter and early spring the largest catches are made off shore, on muddy or sandy bottom. In late spring or early summer the fishermen move their traps towards the shore, and find the best fishing on rocky bottom along the side of kelp or other kinds of sea-weed. But, while the lobster finds a congenial home on a soft sea-bottom, it does not follow that the animal, when compelled to pass the winter in Long Beach pound, necessarily finds the mud therein equally congenial. The mud of the pound has a disgusting odour, largely due to the gas, sulphuretted hydrogen. Every one who is familiar with this gas knows its characteristic odour, and the characteristic odour could be obtained anywhere in the central area of the pound by simply driving a wand down into the mud. For example, at low water on the morning of August 8 a spruce wand six-sixteenths by seven-sixteenths was pushed 5½ feet into the mud by the mere pressure of the hand. This was at the north end of our engine house. At the south end, 3 feet were found. At the south end of our hatching boxes, 5 feet. At all points, on withdrawing the wand, the characteristic odour of sulphuretted hydrogen was experienced, and the adherent mud had all the appearance of a sulphide precipitate.

That the gas was really sulphuretted hydrogen became evident in another way. The gas-ladened mud blackened any board, oar, or boat that was painted with white lead, and which remained in contact with the mud for a few hours. Moreover, it precipitated soluble salts of silver, copper, iron, etc., and there is no doubt that the surface of the gill filaments were darkened and their function partially destroyed by sulphides or other particles of mud. In this way it is easy to understand how the gills of lobsters in the pound gradually turned, first, to a grey colour, and finally became almost black.

Dr. McGill, chief analyst of the Inland Revenue laboratory, Ottawa, made an examination of the mud, the super-natant sea-water, and the gills of an adult lobster which had died in the pound. He reports as follows: "The mud is chiefly silica, with a considerable amount of inter-mixed sulphide of iron. The gills of the lobster contained iron and phosphates, with a possible trace of sulphur."

Dean Goodwin, D.Sc. of the Kingston School of Mining, reports a similar finding to that of Dr. McGill.

MORTALITY.

The severe conditions under which the animals passed the winter seem to have affected their general health and caused a rather high death-rate. Of course, it is quite impossible to estimate the death-rate among lobsters in their natural habitat. In the sea, allowance must be made for those that die of hunger, or are killed by enemies. In the pond and pound the adults have no enemies, and, consequently, should show a low rate of mortality, otherwise there would be no reason for placing them in sanctuaries. We can only form an idea of the rate of mortality in sanctuaries

by keeping track of those which die from year to year, and ascertaining, if possible, the cause of death. For example, of 167 lobsters left in the pond and pound last season (1914) only 134 could be found this season, thus showing a loss of 33. Of the 312 placed in the pond and pound this season (1915) all have been accounted for, the loss by death being a total of thirty-eight. But, just as thirty-three in the one case does not represent the true loss by death (because some of last year's lobsters may yet be recovered from the pond), so thirty-eight does not show the true mortality this year, that is, the mortality due to the ill-effects of detention in the pound or pond. The loss this year must be reduced to twenty, because eight of the thirty-eight were poisoned by the accidental use of red paint on the paddles in one of our hatching boxes, and ten others died in the course of transportation to the pound. The real loss, therefore, this year is only 6 per cent of the total, whereas, the loss on last year's numbers (if no more can be found in the pond) was nearly 20 per cent. The greatly decreased mortality this season is, undoubtedly, due to the great care exercised by the department in collecting, feeding, and distributing them, and the shorter detention period in the pond and pound. No one, who appreciates the facts, will advocate the retention of lobsters in either pond or pound for more than a few months at a time.

EGG-LAYING.

Egg laying at Long Beach this season had two peculiarities. The first was that about half the females extruded only a few hundred eggs in place of many thousands, and the second was that the eggs on probably 80 per cent of the mothers were unfertilized.

In explanation of the former fact (noticed last year also) we at first assumed that the mothers had been interrupted in the act of egg-laying by being dipped up in the net. Subsequent facts, however, showed that this was not the case, because, when such lobsters were confined in crates or cars for a few weeks, the number of eggs was never increased. Secondly, when (as happened on a few occasions) such a lobster died, *post mortem* examination showed that the beast had extruded all the ripe eggs in her ovaries, excepting perhaps half a dozen or so. This great reduction from the full complement of eggs had to be explained on some other grounds. As this peculiarity in egg-laying was limited, so far as the writer can remember, to females which had spent the winter in the pond or pound, the reduction in the number of eggs would seem to be due to the unfavourable conditions under which the animals had lived throughout the winter—crowding in a small compartment, lack of adequate food, excessive growth of algæ upon them, and the uncongenial mud of the bottom. In illustration of this subject, the following facts may be quoted. In one compartment of the pound were fifty females which had hatched their eggs in the summer of 1914 and been retained in the pound all winter. Whether they had extruded eggs last autumn and lost them during the winter or early spring is not known, but, at any rate, they were all found without eggs on April 8, 1915. On July 19 an examination of the 50 resulted, as follows:—

- 22 had no eggs on them.
- 21 had new eggs on them, but none with the full complement. Within a week 4 of these 21 had lost the few eggs which they had.
- 1 only had a full complement of eggs.
- 2 had died.
- 1 male only was present throughout the winter with these females.
- 3 were unaccounted for.

It is probable that few if any of the eggs carried by these twenty-one females were fertilized, because there was only one male present in the enclosure to mate with the fifty females. It happened, unfortunately, at the time of this examination that the rearing apparatus absorbed all my attention, and, consequently, no examination of the eggs was made to see whether they were fertilized or not. Nor must it be supposed that the loss of eggs by four of these females out of the twenty-one was the only instance of the kind which came under our notice this season. On another

occasion a female, which was known to carry a few eggs, was later found to be without any. In a third instance two females, both with eggs, were placed in a crate and a few days afterwards one of them was found to have lost her eggs.

Here, then, we have records of three different occasions on which lobsters lost their eggs a short time after extruding them. If unfertilized eggs "go bad" and drop off within a few weeks or even months after extrusion, it is easy to understand how our fishermen find not more than an average of 20 per cent (according to one member of the Shell Fish Commission of 1912-13) of the females carrying eggs. It may be, too, that mothers, when pressed by hunger, eat their eggs, whether fertilized or not fertilized. I have myself watched a female tearing off unfertilized eggs from her swimmerets, passing them forward and transferring them to her mouth with her maxillipedes. On examining her abdomen, the egg clusters could be seen ragged and torn on each side and partly removed. It could not be said in this instance that the eating of her eggs was the result of hunger, because all the lobsters in the pound this summer were well cared for and regularly fed.

The fourth instance of the loss of eggs was the most remarkable of all. In this case none of the eggs adhered to the abdomen. The first intimation we had that eggs were being laid was seeing them floating around in the current on the floor of one of our rearing boxes. These were all soft and jelly-like, and undoubtedly, diseased and unfertilized.

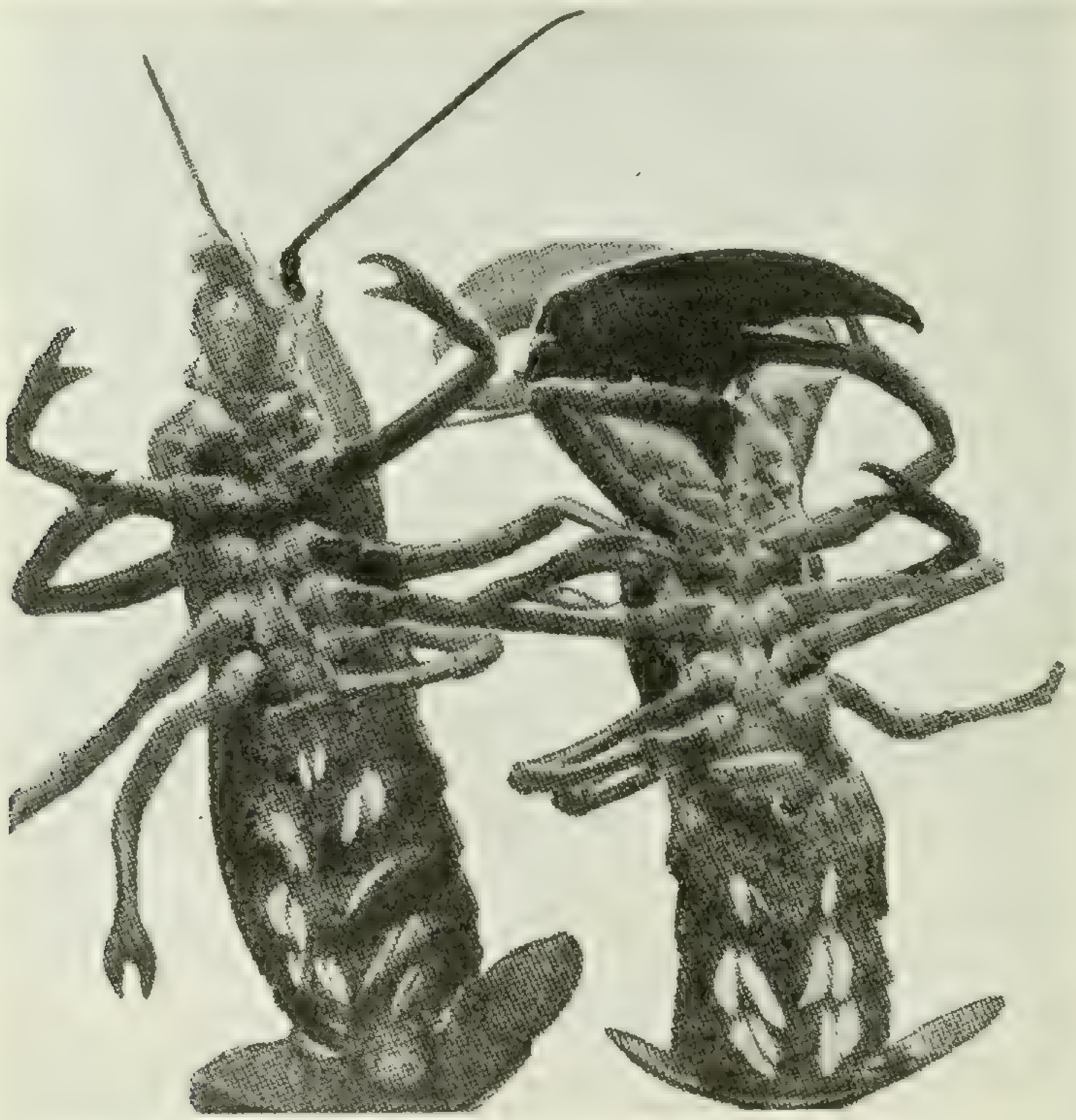

Fig. 4.—Mother lobsters carrying newly extruded eggs. These are attached to the paired swimming feet on the under surface of the abdomen. When carrying eggs, the mothers always bend the latter part of the abdomen and tail under the body so that the eggs are as well protected as if carried in a covered cup. In the illustration the abdomen is extended so as to expose the eggs to view.

MOULTING.

We had opportunities of witnessing several successful moults and also several failures to moult, followed by death. The act is too well known to require description. In healthful surroundings and under the stimulus of adequate food, the act cannot be a critical one for a vigorous animal, but, if conditions are not favourable, as in the pound, then the act may well be fraught with danger. There can be but little food in winter, especially, within the limited area of the compartments, and considering the leakage, the supply of fresh sea-water at low tide must also have been scanty. The slimy mud that covered their gills was an ever-present menace, so that the animals were weakened by their long confinement, and some of them, therefore, unfit to store materials in the body for the manufacture of the new shell or the excretion of waste material from the body. What more likely thing could happen than that some of them would succeed in moulting, while others would fail and die?

BLIND LOBSTERS.

On noticing the blind lobsters, the first question that occurred to me was to ask whether the sight would be restored after moulting. The question was generally answered in the affirmative, but not always. In the case of a female which had spent a year at least, and possibly more, in the pond, it was found that she was still blind. The algal growths had penetrated too deeply into the substance of the eye and had destroyed the underlying tissue. In one other case, the sight was impaired, but not lost; but, generally speaking, the process of moulting restored the sight.

NUMBERS OF EGG-BEARING FEMALES.

It is greatly to be regretted that statistics in regard to the relative numbers of egg-bearing lobsters are not available. The following table from Herrick's book is valuable so far as it goes. Facts of a like kind are given by Vinal Edwards for No Man's Land. Similar facts do not appear to be available in Canada, so far as the writer knows.

RECORD of the Total Catch of Lobsters at Woodshole, Mass., from December 1, 1893, to June 30, 1894, showing the number and size of egg-bearing females.

Length.	No. Males.	No. Females	Females with eggs.	Totals.	Length.	No Males.	No. Females	Females with eggs.	Totals.
in.					in.				
6	3	4	....	7	10⅛	0	1	1	1
6¼	1	....	......	1	10¼	62	71	17	133
6½	3	4	......	7	10½	79	103	28	182
6¾	5	0	......	5	10⅝	1	......	......	1
7	45	47	1	93	10¾	18	18	2	36
7⅛	.....	1	......	1	11	31	62	20	93
7¼	10	4	.....	14	11¼	10	11	.....	21
7½	66	47	....	113	11½	11	30	4	41
7¾	20	9	......	29	11¾	2	2	.	4
8	168	140	2	308	12	9	14	3	23
8⅛	....	1	....	1	12¼	1	......	....	1
8¼	44	29	......	73	12½	4	7	....	11
8½	143	115	7	258	12¾	....	1	1	1
8¾	26	27	1	53	13	4	4	....	8
9	170	166	13	336	13½	1	....	...	1
9⅛	....	1	1	1	14	1	....	....	1
9¼	32	38	4	70	14½	1	2	......	3
9½	148	169	24	317	15	...	3	..	3
9¾	27	29	3	56					
10	167	184	36	351	Totals.....	1,313	1,344	168	2,657

Percentage of females which carry eggs, 12.

Percentage of females with eggs at No Man's Land, 63·7, but that was over twenty years ago, when lobsters were more abundant than now.

These figures indicate that a much higher percentage of females are berried along the Massachusets coast than in St. Mary's bay or the Bay of Fundy. Inquiries made among the lobster fishermen, both last summer and this, go to show that out of every 1,000 to 2,000 adults, only from two to three are found to carry eggs. Is it not time that other statistics besides measurements of length should be collected and published in our annual reports?

In collecting statistics, the important points are: (*a*) the relative numbers of males and females caught during a season; (*b*) the percentage of females that carry mature, or ripe, eggs during the open season; (*c*) the percentage of females which extrude new eggs during July, August, and September; (*d*) and especially, the proportion of these eggs which are fertilized and unfertilized.

With such statistics before us for a few years we should soon know whether we are making good the wastage of lobsters or not. At present we do not know. In a vague way we conclude that, because millions of newly hatched fry are being planted annually in the sea, therefore, we must necessarily be increasing our lobster supply, or, at least, keeping the supply up to the numbers annually trapped by the fishermen. The fallacy of this reasoning is clearly realized by the Shell Fish Commission (1912-13) page 27: "The annual returns, though showing a very large increase in the money value, are really misleading, because, while the supply of lobsters is declining, the price has so materially advanced that the total value is greater to-day than at any previous period."

The results of all our hatching and all our egg-planting, therefore, has not sufficed to replenish our depleted waters: that they have increased the numbers is pure guess work. The same criticism precisely may fairly be made about rearing the fry. We are working away in the dark, increasing the chances of survival, no doubt, but without demonstrable proof of any increase in the numbers of animals which grow to maturity.

Can we not be a little more accurate in our methods? Let us first of all collect for a few years the statistics for which I am pleading. With these as a basis for comparison, let us erect, say, fifty enclosures, 20 feet by 20 feet, at a cost not exceeding $200 each, or $10,000 in all. Impound in these during July and August, twenty-five males and twenty-five females—all carefully chosen and fully mature, and I am confident that we shall get a very large increase in the number of eggs. And after all, the greatest aid in preventing the extinction of the lobster will be to increase the egg bearers. Mother ocean will feed the fry, if we protect the egg producers. But, if we continue to hatch, as has been done in the past, we never know what increase results from our efforts, but we do know that frequently we are feeding fish.

Much desirable information can probably be obtained by circularizing canners and fishermen and explaining clearly to them the objects which the department has in view.

In fact, Mr. W. S. Trask, a canner at Little River gladly gave me such information as he had at his disposal. From May 10 to June 15 he bought 7,151 adult lobsters from fishermen. He did not take the time (nor did the fishermen) to distinguish males from females, but he was confident from some observations which he had made a few years before, that there were generally more females than males. Out of the 7,151 adults which he had purchased, only thirty-five carried eggs, that is, 1 per cent, on the assumption that the sexes are equal in numbers. How can the lobster industry be kept up, if only one mother out of every 100 bears ripe eggs?

Probably few females are ever sterile. When eggs are not fertilized, one cause will probably be the lack of facilities for mating. This, at least, was apparently the

NOTE.—Mention should be made of the information collected by Mr. Halkett at Baker's Pond, C.B., showing the relative percentage of males and females there to be about 46 males to 54 females per hundred.

cause this year at Long Beach. Up to to August 2, forty-three females had extruded eggs, and careful examination of twenty-eight of these showed that only five carried fertilized eggs. The reason of this seems clear enough. With the fifty females which wintered in the pound, there was, as already stated, only one male. Whether this one male could fertilize the eggs of forty-nine females is certainly open to question.

It is true that the department placed thirty males and thirty females (commercial) in the pond or pound for experimental purposes this season, but, unfortunately, eight of the males were poisoned, several of them were undersized, and six others died from causes unknown. It will thus be seen that, if we take into account the relatively small proportion of males to females, and the unfavourable conditions in which both sexes were confined in the pound—I refer to the mud, not to feeding, which was carefully done,—it is not much wonder that many of the extruded eggs remained unfertilized, then softened and dropped off.

ANNUAL SPAWNING.

It was intimated in my report for 1914 that some females which had extruded eggs in August of that year were to be retained in the pound all winter, and might throw some light upon the subject of annual spawning. Of forty-seven females placed in the pound in midsummer, 1914, thirty had extruded eggs by the end of September. There were confined with these females, fifteen males. Leaving out of consideration ten females which were under 10 inches in length, the proportion of full-grown males to females was 15 to 37, or nearly 1 male to 2 females. The result was that on the 8th of April, 1915, when these thirty females were again examined, all bore fertilized eggs. In other words, 64 per cent of the females placed in the pound last June carried fertilized eggs to June of this year. As a matter of fact, most of the eggs were "laid" in August, but the important point is the large number of berried females which resulted from the experiment. These animals were not examined again until July 7, 1915, when the following results were found:—

12 had no eggs on them, being probably hatched off in the interval between April 8 and July 7.
12 were in the act of hatching their eggs.
2 had newly extruded eggs upon them.
1 was dead.
1 was lost off the dip net in removing it from the compartment.
2 could not at that date be accounted for, probably hidden in the mud.
—
30

The twelve which had old eggs upon them on April 8, but were without eggs on July 7, were placed in a compartment by themselves and re-examined again on July 29, when seven of them were found to be carrying newly extruded eggs.

These seven females with the two which bore new eggs on July 7 make a total of nine, which had carried eggs in 1914, and again extruded eggs in 1915. The remaining five of the twelve escaped from the enclosure in which they were confined, and, as a consequence, it became impossible to identify them from others in the pound, but so far as these nine lobsters are concerned, annual spawning is an undoubted fact.

One female, at least, of these seven, bore "bad" eggs, and one other, though the eggs appeared normal and of the usual number, nevertheless, carried unfertilized eggs, as shown by microscope examination.

MORE FERTILIZED EGGS.

The problem of problems in the lobster industry is not how to rear fry to the crawling stage, but how to increase the number of females which carry fertilized eggs.

The artificial hatching of lobster eggs may be important, though many doubt it; the artificial rearing of lobster fry to the fourth or fifth stage may be important, though this remains to be proved, at any rate in Canadian waters; but the biggest of all lobster problems is how to increase the number of fertilized eggs. Unfertilized eggs are probably produced in vast numbers, if biennial spawning is the rule; in vaster numbers still, if annual spawning is the rule.

Reverting again to the 7,151 adults bought by Mr. W. S. Trask this season, among which he found only thirty-five berried females, and to Mr. J. W. Tidd's catch of 3,000 lobsters in 1913, among which he found only three berried females, we are faced with the problem of explaining how it happens that there were not about 3,500 berried females among Mr. Trask's purchases, if lobsters spawn annually, or 1,750 if lobsters spawn biennially, similarly with Mr. Tidd's catch, and with the catch of every lobster fisherman in the Maritime Provinces.

We have no knowledge of the extent to which the sexes mingle with each other in the sea. Conclusions based upon the tagging of lobsters and their subsequent liberation and capture may be misleading. Tagging does seem to indicate, however, that they are strongly local in their habits, and, if so, they may meet each other only at intervals and solely by accident. How different conditions are to-day for mating, compared with what they were in early colonial days when lobsters were so abundant along the Atlantic coast that after every storm they were found lying along the shore in windrows!

If the facilities for mating are lacking, this may be the reason why so few females carry fertilized eggs. If there is no mating, the mothers will extrude their eggs annually or biennially, as the case may be, but the eggs, being unfertilized, will "go bad" and subsequently drop off.

It must not be supposed, therefore, that the eggs found in June, July, August, and September on berried females are necessarily "good eggs." For breeding purposes they may be as useless as those of a pullet with which no cockerel has cohabited. As illustrating the truth of this statement, it is only necessary to point out that of twenty-eight females which extruded eggs in Long Beach pond this season, only five were found to carry fertilized eggs. These results are quite different from those of last year, but the conditions were different in the two years. In 1914 the mating lobsters were placed in a compartment specially located near the entrance of fresh sea-water from the intake pipe, and by the end of the season, as already stated, 64 per cent of the females carried fertilized eggs, as compared with 1 per cent reported by fishermen. In the case of the mating lobsters of this year, 1915, some of them, were placed at first in the pond and others of them in the pound. Subsequently they were transferred to two of our rearing boxes, and later again to the third compartment of the pound. Considering, too, that there were only 26 males to 109 females and that the transfer from one enclosure to another was unnatural; considering also the unfavourable conditions under which they lived in the pound, one can readily understand that copulation took place less frequently than under the more natural conditions of 1914. But after making every allowance for the conditions which militated against the extrusion and fertilization of eggs, we find that 44 out of 109 females extruded eggs in the summer of 1915, or over 40 per cent.

When it is remembered that the Shell Fish Commission estimated from their inquiries that the percentage of berried females ranged from 2 per cent to 40 per cent,* and that this latter percentage existed only where fishing is permitted in June and July, as in Northumberland strait, and when it is considered also that in these months some lobsters are carrying old eggs and others are carrying new ones, it will readily be seen that the 40 per cent does not represent the true proportion of newly extruded eggs at all. Let us find out, if possible, the correct proportion of hen-lobsters which carry new eggs, or of those which carry mature eggs, but not a combination of the two.

* These figures were obtained not from the Commission but by correspondence with only one member of the Commission.

MATING GROUNDS.

So few facts are known in regard to the mating of lobsters that special attention should be given to this subject next year. While the pound has proved to be useless this season as a suitable place in which to rear fry or retain adults, the southwest end of the pond, as stated in last year's report, could be made very useful, both as a sanctuary for beried females and as a mating ground for commercial lobsters. If the compartments at present in the pound were removed to the southwest end of the pond, and the cost of doing this need not exceed $200, there would then be ample space for both sanctuary and mating ground and better conditions than prevailed this past summer.

It cannot be stated too often that the great problem is how to increase the number of fertilized eggs. The hatchery cannot add a single fry to those which the mother will hatch out. On the contrary, the hatchery often starts them upon their ocean life, infected with diatoms, as shown by Professor Gorham. The rearing plant guards and feeds the fry for a brief three or four weeks, and then liberates them to take their chances in wind and tide and among a multiplicity of voracious enemies. In contrast with the uncertainty of hatching and rearing fry, an increase in the number of females carrying fertilized eggs would mean an incalculable increase in the number of fry, and consequently, a better chance of survival until they become adults.

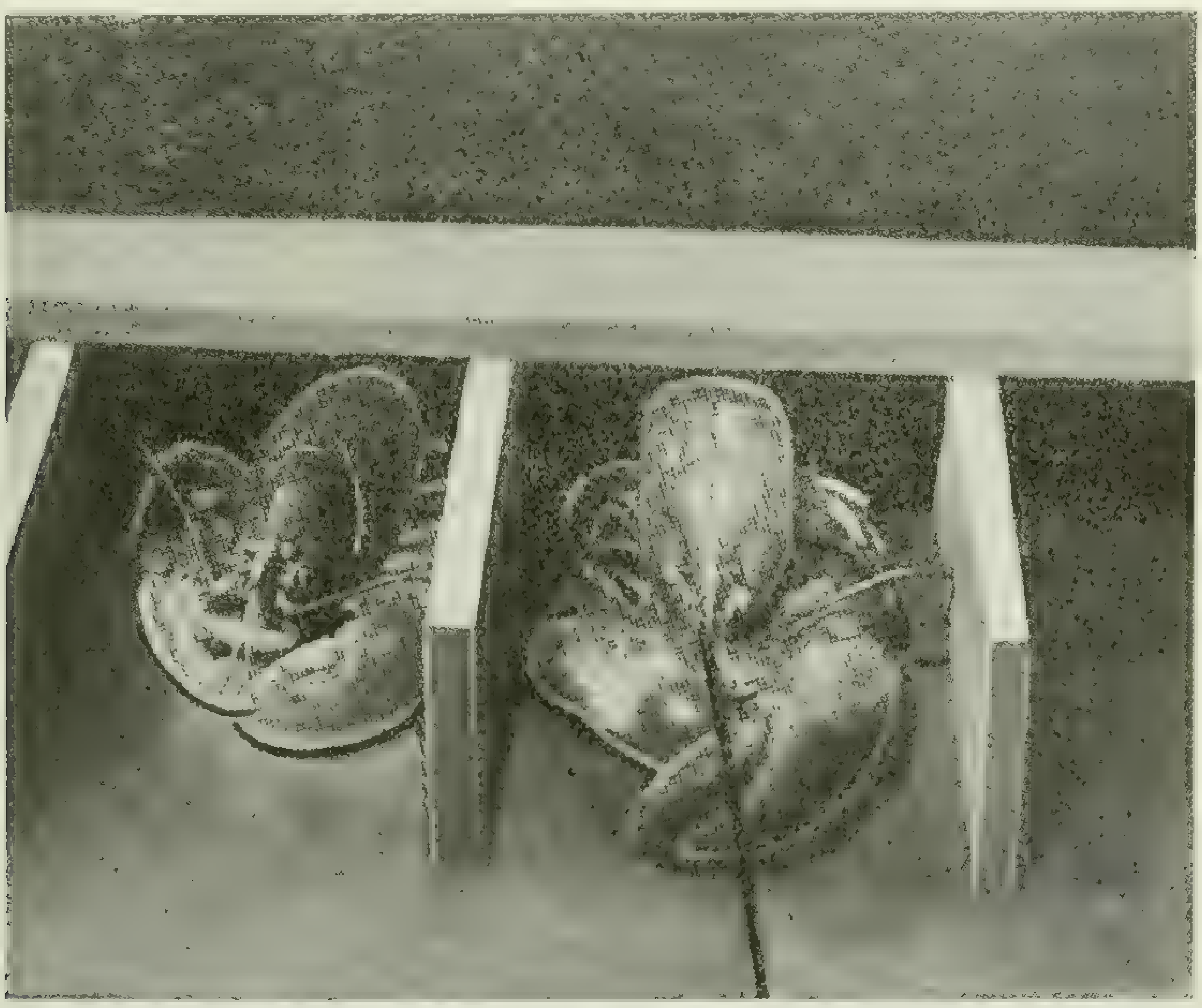

Fig. 5.—Two lobsters resting in their shelters.

To realize how greatly the number of berried lobsters may be increased, as they were actually increased in the pound in 1914 from 1 per cent to 64 per cent, we have only to consider how rapidly a farmer could increase his poultry if he bred from sixty-four hens out of a hundred, instead of from one hen. He might use a hatching apparatus (as we do for lobsters) and a rearing apparatus also, if there is such a thing for chickens, but the increase in his poultry would be slow indeed, compared with what it would be if he bred from sixty-four mothers in place of from one. If we could come anything near increasing our berried lobsters from 1 per cent to 64 per cent, we might burn down our lobster hatcheries and never notice the loss, so far as the lobster industry is concerned.

Of course, there may be other causes at work, besides lack of facilities for mating, to account for the small number of berried females. If so, these causes must be studied and, if possible, removed. But, at any rate, no one can be blind enough to overlook the significance of the mating experiments of last year and this.

THE EVERYDAY LIFE OF THE LOBSTER.

While our lobster-rearing experiments at Long Beach pond, both last year and this, resulted in failure, it cannot be said that the two seasons' work was entirely barren of results. Apart from the observations which have been made on mating, and which, it is hoped, may prove even more useful to the lobster industry than any success which might have been achieved in lobster rearing, we have been able to make some contributions to our knowledge of the every day life of the lobster.

Very early in our operations of this year it was decided to use but two rearing boxes, instead of four. The other two were fitted up with shelters, or nests, for the study of adults.

Observations were made every day from July 20 to August 6, when the animals had to be removed. The excesive leakage from the pound left our boxes resting in the mud, and contributed not a little to bring about the death of several adults, through the lack of properly aerated water.

POSTURES.

When performing certain functions, for example, cleaning themselves, egg-laying, fighting, etc., the adults took up certain appropriate postures. One of these, which may be spoken of as the cleaning posture, was first observed among lobsters which had wintered in either pond or pound. Within a week after these animals had been placed

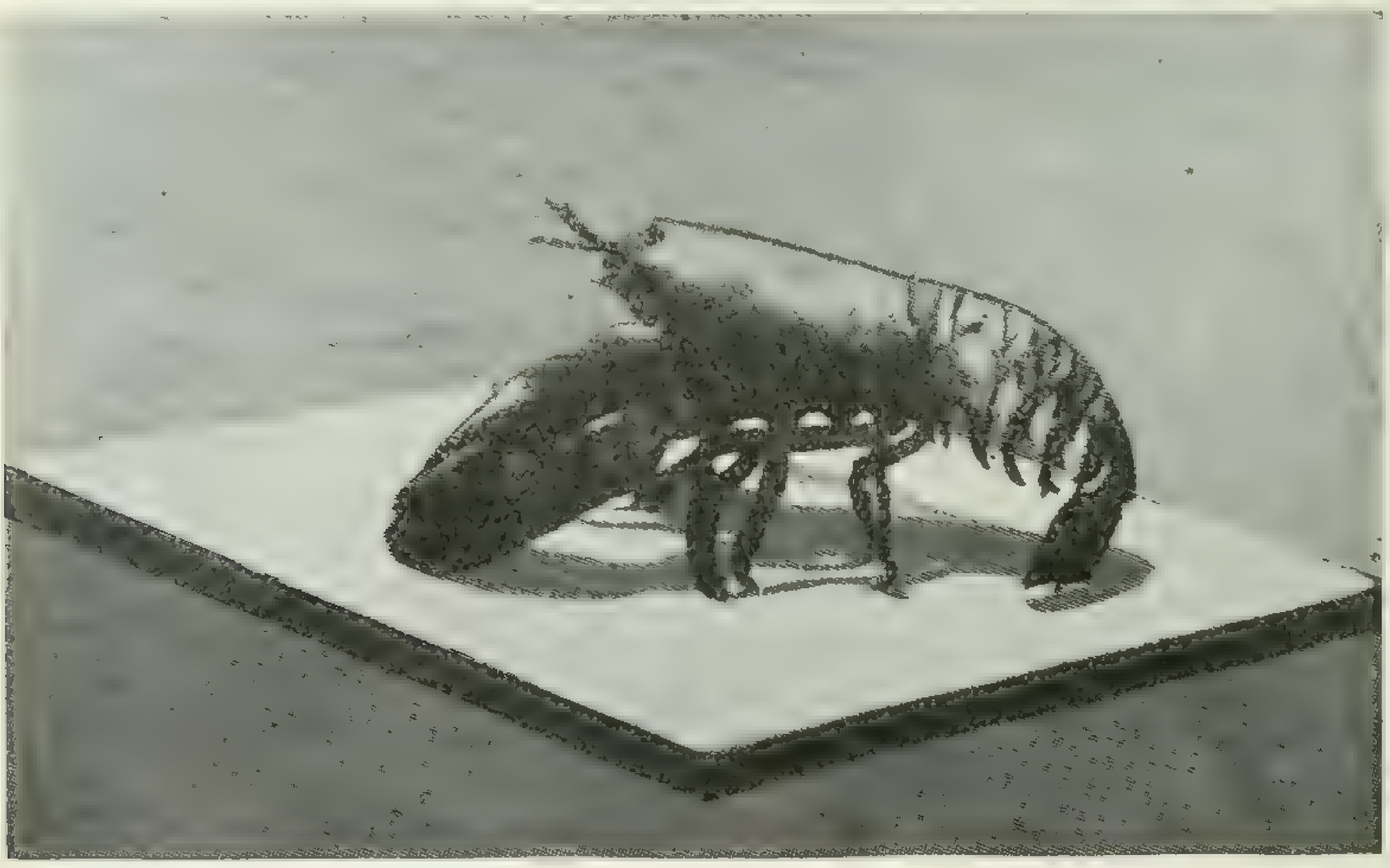

Fig. 6.—This illustration is from a lobster cast which has been shaped to resemble the posture of a mother lobster when hatching her eggs. The swimmerets are visible under the abdomen and these are moved gently backwards and forwards in the water so as to assist in liberating the young from the "shell". This same posture is taken when the animal is cleaning itself.

in the rearing box, their appearance had changed very much for the better. No lady in the land could spend more time on her toilet than these lobsters did in cleaning themselves. They did not, of course, wash, massage, paint or powder their faces, nor did they curl their hair, but they did spend days and days in attempts to free themselves from the excessive growth of algæ, which covered almost every part of their body.

At first they ate voraciously; later on, much more moderately. Their only toilet instruments were the opposable thumb and finger (pincers) of their walking legs. Every part of their body which could be reached by those appendages was carefully gone over. It was no uncommon thing to see a lobster raise the first pair of walking legs over the great claws and use them in cleaning the rostrum and antennules. The antennæ (feelers) would be grasped by the pincers and drawn through between the thumb and finger, thus stripping off algæ and dirt, in much the same way as a person might strip off the excess of dirt from a string by drawing it through between his thumb and finger.

When thus cleaning themselves, the animals rest almost entirely upon the tips of their great claws and the telson which is bent at right angles to the long axis of the body. The middle region is arched slightly upward, and the walking legs are thus left almost completely free for cleaning movements.

THE HATCHING POSTURE.

This posture has often been described and does not differ from the cleaning one, excepting that the animal rests on its walking legs as well as on its great claws and telson. The movements are limited to a gentle swaying backwards and forwards of the swimming feet, evidently for the purpose of assisting the fry to liberate themselves from the egg capsule (shell).

EGG-LAYING POSTURE.

The egg-laying posture, as we saw it, was different from that described by Anderton. The general position is that of a more or less erect frog. The abdomen is bent completely under the body, and the broad tail is well spread out on each side, so as to form an almost perfect cup. The anterior part of the body is inclined at an angle of nearly

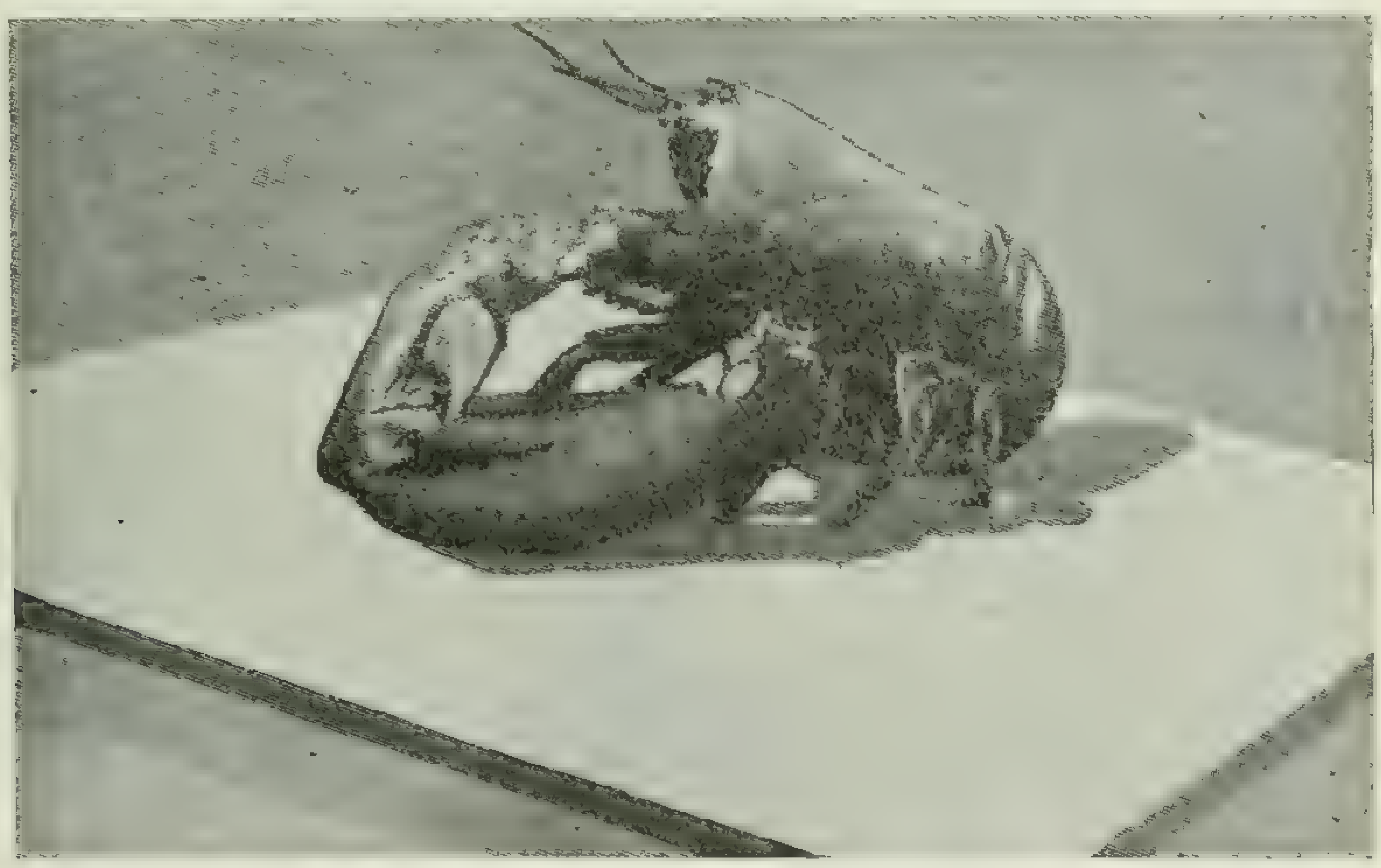

Fig. 7.—The egg-laying posture.

45°, on account of the animal resting on the tips of the great claws. The posture is such as to allow the eggs, as soon as they leave the orifice of the oviduct, to fall by gravity over the receptaculum seminis and drop easily and naturally into the abdominal cup already described. After the eggs have filled the cup, the female turns upon her back for 15 or 20 minutes and remains almost motionless, the walking legs alone swaying backwards and forwards at intervals of a minute or two. During this quiet period the egg glue is apparently hardening so as to fix the eggs to each other and to the hairs of the swimmerets.

That the egg glue requires time to harden in the water was demonstrated by the fact that one female, which was lying on her back after egg-laying, was dipped up too soon from the box and righted in position. As a result, nearly all her eggs dropped off on the board on which the observer was standing.

THE RESTING POSTURE.

This is the posture which an animal naturally adopts when left to itself in a crate, box, or other enclosure, and usually after being fed. If there are many animals

Fig. 8.—The resting posture. From a photograph of an animal under water.

together, they will often take up this posture in one corner and lie one on top of the other. It is their usual posture in shelters.

FIGHTING POSTURE.

There is nothing new to describe about this posture. Most people who have watched lobsters when removed from the water have seen them elevate their great claws, open their scythe-like jaws, and otherwise adopt a threatening or defensive attitude. It is the regular pose of female lobsters, in defence of their eggs, and of the male lobsters towards each other. Time after time have we seen two males pass females without adopting any belligerent attitude, but as soon as they approached each other "squared off" for a fight. Though the males are generally restless, the larger ones chasing the smaller from place to place, we never actually saw one injure the other.

BIENNIAL SPAWNING.

It remains to say a few words on the subject of biennial spawning. The fact that nine lobsters spawned in 1914, and again in 1915, is beyond all question. It is also equally beyond question that out of 50 lobsters which hatched their eggs in July, 1914, and moulted in the autumn of 1914 (according to the testimony of the caretaker of the pond) twenty-two did not spawn this summer at all. If lobsters spawn biennially, then these females should have extruded new eggs in July and August of 1915, but they did not.

From the evidence which we have collected thus far at Long Beach, it is quite clear that some lobsters spawn annually, some biennially, and some do not spawn even biennially. Of course, it is only fair to point out again that the conditions in both pond and pound are unnatural, and, therefore, we need not be surprised when we meet with departures from the normal habits of the animal, whether the habit be annual or biennial spawning.

A REVIEW.

In looking over the operations of the pound for the past two years, let it be frankly acknowledged at the outset that the main purpose for which it was built has not been realized. Can it be fairly said, then, that the money spent in the purchase of the pond and the construction of the pound has been wasted? I think not.

In addition to being a sanctuary for berried females, the pound has brought about the discovery that the numbers of lobsters may be increased by bringing the sexes together. This, of course, was not the primary object for which the pound was built. So far as can be judged from public reports and from the Board's correspondence with the Fisheries Branch, the discovery was made by accident. Sixty-two commercial lobsters were sent to the pound in 1914 for the purpose of observing whether lobsters spawn annually or biennially. Long before a conclusion could be reached on the subject, it was discovered that 64 per cent. of the forty-seven females in the pound had extruded fertilized eggs—a most astonishing fact, when every fisherman in Digby County knows that only about one female in every hundred carries eggs. This opinion of the fishermen is corroborated by Mr. Andrew Halkett. In his report upon the Baker Lobster pound, Cape Breton, 1909-10, page 16, he mentions a trip which he took with Rafuse & Son, fishermen, to seventy-five traps, containing altogether fifty-six males and sixty females. Only one of the females was berried.

Why this great difference in egg-bearing between open-sea lobsters and those in Long Beach pound? One obvious explanation is that it is due to the close intercourse between male and female lobsters in a compartment 20 feet long by 10 feet wide. The fact that 40 per cent. of the females at Long Beach this summer (1915) extruded eggs under most unfavourable conditions appears to corroborate the discovery. At any rate, the results of the two years' observations, in my judgement, amply justify the department in building a few more enclosures at different points along the maritime coast in order to test still further the extent to which egg-bearing may be artificially promoted.

Surely the expenditure of money on industrial and economic problems is one of the functions of Government. If it is not, then much of the expenditure on Experimental Agricultural Stations and on investigations into our peat and other mineral resources is unjustifiable. Far, however, from the money hitherto spent upon such scientific investigations being wasted, it is money well spent. Similarly, I trust it will be realized in a few years that the money spent upon Long Beach pond will have been amply justified either by the direct or indirect scientific results that have been achieved.

III

THE PEARLY FRESH-WATER MUSSELS OF ONTARIO.

By John D. Detweiler, M.A., St. Andrew's College, Toronto.

(With one figure in the text).

INTRODUCTION.

As a part of the pearly fresh-water mussel investigation, conducted by the Biological Board of Canada, a number of localities, from which promising reports had come in, were visited in August, 1916.

The investigation had a twofold object: first, to determine the abundance, species and commercial value of the mussels; and, second, to ascertain whether it would be advisable to introduce artificial propagation in any Canadian waters.

In order to facilitate the work, the Board decided to send the author to the Fairport Biological Station at Fairport, Iowa, so that he might thoroughly acquaint himself with the problem in hand.

THE UNITED STATES FISHERIES BIOLOGICAL STATION, FAIRPORT, IOWA.

This station was established in 1908, and is the centre of mussel propagation and of the investigation of problems relating thereto.

In the practical propagation of mussels the station serves as headquarters for field operations conducted throughout the Mississippi basin, including the Mississippi river and its tributaries. There may be in the field at one time from two to six field parties operating near the station or at a distance of several hundred miles. For full account see United States Bureau of Fisheries, Document 829, by Dr. Coker.

METHODS AND TECHNIQUE OF ARTIFICIAL PROPAGATION.

The methods of propagation are based upon the peculiar character of the normal course of development of the fresh-water mussels. The young mussels, with rare exceptions, when first liberated from the mother clam must become parasitic upon a fish in order to pass through the next stage of their development. To this end these young mussels—glochidia, as they are called at this stage—attach themselves to the fins or gills of a fish, if the opportunity presents itself. They already have two shells which under proper stimulus work like a small trap, and a very slight wound seems to be produced which after attachment begins at once to heal over. In this way the glochidia become more or less safely encysted and now virtually live the life of parasites, subsisting on the juices of the fish. In the course of two weeks, more or less, having completed their metamorphosis, they break away from their host, drop to the bottom and begin an independent existence.

If not over-infected, the fish seem to suffer no injurious effects. Naturally, the limit of successful infection depends on the size and nature of the fish. Careful investigation of natural and artificial infection has shown that a moderate sized fish may carry successfully from 1,000 to 2,000 glochidia.

Mussels do not attach themselves indiscriminately, but for each species of mussel there is a limited number of species of fish that may serve as host. In some cases the number that may act as a host is apparently very exclusive. In this connection

it may be mentioned that the gar, including at least the two species *L. platostomus* and *L. osseus*, has been found to be practically the only host for one of the most desirable of shells, the Yellow sand-shell *(Lampsilis anodontoides)*.

In actual artificial infection of fish the operation is essentially as follows: The gravid mussels and their suitable fish hosts are placed in a vat or tub containing a requisite amount of water. The mussel is now opened, the marsupial pouch split open along its ventral border and the glochidia are squeezed out into one of the valves of the mussel, which valve also serves as a small water container. The glochidia are then poured into the tub and the water agitated, more or less, so that they will be kept in suspension. From time to time individual fish are caught and gills examined to determine the extent of infection. The optimum amount of infection varies for different sizes and species of fish and also for the condition the fish are in. It is generally accomplished within the limit of 5 to 20 minutes. Over-infection must be guarded against.

Naturally, there cannot be any definite rule as to the number of glochidia to be used with any number of fish, the person in charge must be guided by his experience.

When sufficiently infected, the fish are removed to the river or pond. If development in the gills is to be watched, they may be transferred to crates anchored in the river or pond.

The gravid female clams may generally be found by looking over material where fishermen are at work. Unless the glochidia are sufficiently developed, the operation is useless, for not until then will they open and close their valves when stimulated. The fish are caught with the seine or net.

From this it will be seen that the experimental shell-fish station and the fish-cultural station go hand in hand. In fact it is a point of economy to combine the two.

Although artificial infection would appear to be a comparatively simple operation, a working knowledge of the process has only been obtained as a result of careful and laborious research. As yet only a few species of mussels are thus propagated. The search for natural hosts is still being prosecuted. Experimental work is also being carried on with the object of determining the period of parasitism, and the life history of the young mussel after parasitism, and to lead to such improvements of methods as will make the work most productive of practical results.

It is interesting to note that within a period of two years, young mussels of sufficient size to cut and finish buttons from their shells were reared at the station. These were raised from artificially infected fish, which were kept in floating crates or in earth ponds. They are not only the first mussels to be reared to such a size from artificial infection, but they are the first commercial forms known to have been grown in ponds.

RESULTS OF ARTIFICIAL PROPAGATION.

Although there is no means of definitely checking up the results of artificial propagation on a large scale, where the mussels already exist, yet the extent of the confidence the United States Government has in the undertaking may be shown by the fact that during the last fiscal year, 331,451,490 glochidia, in round numbers, were liberated in the parasitic condition and 424,550 fish were employed in the operations.[1] It is believed that a considerable proportion of the glochidia fall upon unfavourable ground, or fail to reach maturity from other causes. However, since a large number can be liberated at a comparatively small cost, the attempt is deemed justifiable. So far restocking, only, has been attempted, and in general fishermen report that where artificial infection has been carried on, more young shells are found

[1] Annual Report of the Commissioner of Fisheries to the Secretary of Commerce for Fiscal Year ended June 30, 1916.

than ever before. Such encouraging reports have come in from Lake Pepin, Wisconsin; White and Black rivers, Arkansas, and from Fairport, in the vicinity of the station.

THE SOJOURN AT THE STATION.

My sojourn at the station, July 25, August 3, was both highly profitable and very pleasant. Laboratory accommodation and facilities were freely offered. Valuable instruction, demonstrations and advice were gladly given by the Director and his staff. By assisting in the examination of gills for natural infection, and in carrying out artificial infection under the supervision of an experienced man, I was enabled to get a working knowledge of the operations, which would have been quite impossible to obtain otherwise.

The kindness with which I was received, the consideration shown for my wants and comfort, and the pleasure taken in facilitating the object of my visit were beyond my highest anticipations. In this connection I wish to particularly mention Mr. A. Shira, the Director; Mr. Canfield, Superintendent of Fish Culture; Prof. Clark and Dr. Howard, Scientific Assistants; Mr. Gorham, Foreman, and Mr. Southall, Shell Expert. The Station has also kindly sent me a set of classified shells, thereby facilitating classification here.

ORIGIN OF OUR LARGER MUSSEL FAUNA.

The identity of the mussel fauna of certain Canadian areas with that of the Mississippi waters at once suggests a probable common origin. Our forms no doubt migrated northward on the retreat of the ice cap which is believed to have covered northern North America during the great ice age. As this ice field retreated toward the North West, numerous lakes were formed, now represented by our modern Great Lakes, and these probably all except lake Ontario drained into the Mississippi system. Several of the old drainage courses have been discovered, among them being the ancient Lake Erie outlet, by way of the Wabash into the Mississippi river, and the glacial lake Chicago along the Chicago river. Even lake Superior appears to have had a watercourse into the Mississippi by way of the St. Croix river.[1] Numerous species of mussels no doubt found their way up these waterways into the ancient lakes, and ultimately populated the rivers now flowing into them.

THE GRAND RIVER.

As far as I have been able to ascertain, the Grand river contains more mussels of commercial value than any other Ontario waters. This river rises in the township of Melancthon, Dufferin county, within a distance of almost twenty-five miles from Georgian bay. Its source, at an elevation of approximately 1,700 feet above sea-level may be said to mark the highlands of the southwestern Ontario plateau. From its source to its outlet into lake Erie, at Port Maitland, by the river, the distance is 175 miles and the drainage area is approximately 2,500 square miles. The drainage basin is wide at its headwater area, and narrow in the lower flat country, where most of the rivers flow directly into the lake.

The river may be topographically divided into two parts—upper and lower. The upper part extends well into Waterloo County and includes the Conestogo tributary. Here, on the flat headwater table lands, the declivity is small; then for a distance becomes quite steep. At Elora, for example, there is a single drop of over 40 feet where the river enters a limestone gorge. The fall of the lower river is gradual and uniform, and generally becomes flat towards the lake. The following table will show the approximate fall of the whole river.

[1] Pop. Sc. Monthly XLVI No. 2, p. 217. U.S. Geol. Survey Monographs, XXXVIIa.

TABLE I.—DISTANCE from Port Maitland approximate in sea level.

Place.	Mileage.	Difference	Elevation	Difference, Lake Erie Level.
Port Maitland	0	7	573·94	0
Foot dam, Dunnville	7	0	573·94	7·06
Water above dam	7	22	581·00	13·00
York	29	5	594·00	16·00
Foot dam, Caledonia	34	0	610·00	8·00
Top dam, "	34	0	618·00	0
Behind dam, "	34	16	618·00	1·00
At mouth, Fairchild's	59	10	619·00	20·00
Cockshutt Bridge, Brantford	60	4	639	5
Foot lower dam, "	64	0	644·00	14·00
Behind " "	64	3	658·17	17·00
Behind upper dam, "	67	9	675·00	5·00
Below dam. Paris	76	0	680·00	8·00
Behind dam, "	76	7	688·00	114·00
Bridge, Glenmorris	83	7	802·00	51·00
Foot dam, Galt	90	0	853	9·00
Above dam, "	90	30	862·00	156·00
At Bridge, Conestogo	120	15	1018·00	.....
At Elora	135	Total head 5	.....	Both dams 56 ft.
At Fergus	140	Total head 7	.....	" " 38 ft.
At Bridge, Belwood	147	Water level	1367·00	.....

In the upper stretches of the river, including its tributaries, extending roughly to the vicinity of Paris, the stream-bed is composed of rocks and course gravel almost throughout, and flows in places over exposed limestone for considerable distances. From Paris southward the bed consists chiefly of:—

TABLE No. 2.

Vicinity—	*Nature of Bed—*
Paris to Brantford	Gravel, sand.
Western Counties canal	Gravel, sand, silt and clay.
Brantford to 12 miles below	Gravel, sand and clay.
To Caledonia	Fine gravel, sand and silt.
Caledonia to York	Gravel, exposed limestone.
York to Dunnville	Fine gravel, sand and silt.
Dunnville to Lake	Largely silt.

This section of the province, in common with all southwestern Ontario, is occupied throughout by comparatively undisturbed limestone and other Silurian and Devonian strata with overlying drift, clays, sands and more recent superficial deposits. The deep deposit of drift material naturally lends itself to erosion, and consequently the river carries considerable quantities of sand and gravel during heavy floods, scouring the channel from the headwaters to below Brantford. Below this point a large area of the river channel with the small declivity produces such a condition that light deposits may take place rather than the scouring of the bed to any extent. All the tributaries also bring down large quantities of material.

DISTRIBUTION OF MUSSELS.

Some years ago when repairs were being made on the feeder canal at Dunnville, shells were found in such abundance that they were picked up by the wagon load. This discovery led to the establishment of a small shelling industry at this point. Last year (1915) 265 tons were shipped from Dunnville, and this year approximately 260 tons.

Two or three years ago, during low water, three men picked up and shipped five or six car-loads from a point about one or one and one-half miles below York, and shipped, it is reported, to Buffalo.

From the lower dam at Brantford to the old power-house at Echo Place, there is what was at one time a barge canal, about 1¾ miles long. Where cuts were made it is about 50 feet wide and 5 or 6 feet deep. There is still in this system Mohawk lake, three-eighths of a mile wide by one-third mile long and 20 to 30 feet deep in places. Six or seven years ago, when the water was let out for repairs, this was the best place in the immediate vicinity of Brantford for clams, as to size, quantity and variety.

It is said that about ten years ago clams were abundant at a point about half way between Brantford and Paris, called Mulloy's Farm.

I am also informed by the city engineer of Brantford that large numbers of clams are to be found in the vicinity of Bow Park farm.

The fall on the Speed river, a tributary of the Grand, is well utilized, and clams of good size are found behind nearly all the dams which hold back the water over a considerable area of storage basins.[1]

SPECIES AND CHARACTERISTICS OF SHELLS.

I have twice visited the Dunnville area, and found a considerable variety of mussels of commercial value. My investigation there was much facilitated by Mr. H. Clark, who superintends the shell-fishing. In discussing the mussel fauna, only such species as are of commercial value will be considered.

In the following list common names are also given along with the scientific ones:—[2]

Scientific Name.	Common Name.
Lampsilis alata, Say	Pink heel-splitter.
Lampsilis luteola, Lam.	Fat mucket.
Lampsilis recta, Lam.	Black sand-shell.
Lampsilis venticosa, Barnes	Pocketbook.
Obliquaria reflexa, Raf.	Three-horned warty-back.
Quadrula lachrymosa, Lea.	Maple leaf.
Quadrula plicata, Say.	Blue-point.
Quadrula rubiginosa, Lea.	Wabash pig-toe.
Quadrula undulata, Barnes.	Three-ridge.

No doubt this list does not contain all the species of commercial value found in this district. I have, in fact, picked up the Fluted-shell, *Symphynota costata,* Raf., a good many miles north of Dunnville, and it likely occurs here. I might in passing mention *Lampsilis gracilis,* Barnes, (Paper shell), a large mussel found here, but which is of no practical value on account of the thinness of its shell. Of the above species those most commonly occurring are *L. alata*, *Q. plicata*, and *Q. undulata*. *L. alata* is a good-sized heavy clam, quite a large number of the shells weighing in the neighbourhood of a pound, but its value is much reduced for button manufacture on account of its usual pink or purple colour. *Q. plicata* and *Q. undulata* are similar in appearance and comprise the chief commercial species of this area. They grow to a large size, and as a rule have a good white lustre. I have in my collection one of the former species weighing 1⅝ pounds, and of the latter, one 1$\frac{7}{32}$ pounds in weight. *L. luteola* is naturally a valuable shell, as its quality is excellent, and it cuts and finishes with least waste. The area around Dunnville, however, does not appear to be particu-

[1] I am indebted to the Hydro-Electric Power Commission office at Brantford for valuable data, and also for reports on clam distribution on the Grand river system.

[2] For nomenclature see Synopsis of Naiades, or pearly fresh water mussels. Proceedings, U.S. National Museum, Vol. XXII, No. 1205, 1900, Charles T. Simpson.

larly favourable to its development. It may perhaps be found more plentifully and of better quality farther up the river in localities more nearly approximating the condition in lakes. The other species are of good quality, but owing to their scarcity in this area, have little commercial importance.

METHODS OF THE DUNVILLE MUSSEL FISHERY.

On my visit to the fishing grounds at Dunnville I found two gangs of men at work on the river above the town; one at a distance of about two miles, and the other some five and one-half miles farther on, near Morgan's island. In the former locality they had a pile of shells which would weigh about five tons. These were fished and shelled in about three and one-half days, by two men and two boys. The men did the fishing, while one boy ran the gasolene launch and the other removed the meat from the shells. The outfit for procuring the clams consists of two scows fastened rigidly together by a plank at each end. The distance between the scows is 4 or 5 feet. The men stand on the stern plank while operating the scoops. The scoop, or dip-net is a dipper-like apparatus with a handle of from 12 to 18 feet in length. The bowl consists of a wire cage about 16 inches in depth, and is attached to a triangular iron frame, 16 inches to a side. Thus the opening of the scoop is triangular and works in the manner of a dredge. To assist in the raking of the beds by this scoop, a number of iron spikes about 3 inches long are fastened to the lower part of the triangular frame, and are set about 3 inches apart. This helps to draw the scoop into the river shown and are set about 3 inches apart. This helps to draw the scoop into the river bed. A line passes from the lower end of the scoop to the forward plank and this is of such a length as to allow the handle to stand vertically against the stern plank. The whole outfit is towed by a gasolene launch. The scows, though varying in size, are about 16 feet long by 3½ feet wide and 14 inches deep. The following diagram may serve to illustrate the fishing outfit in operation:—

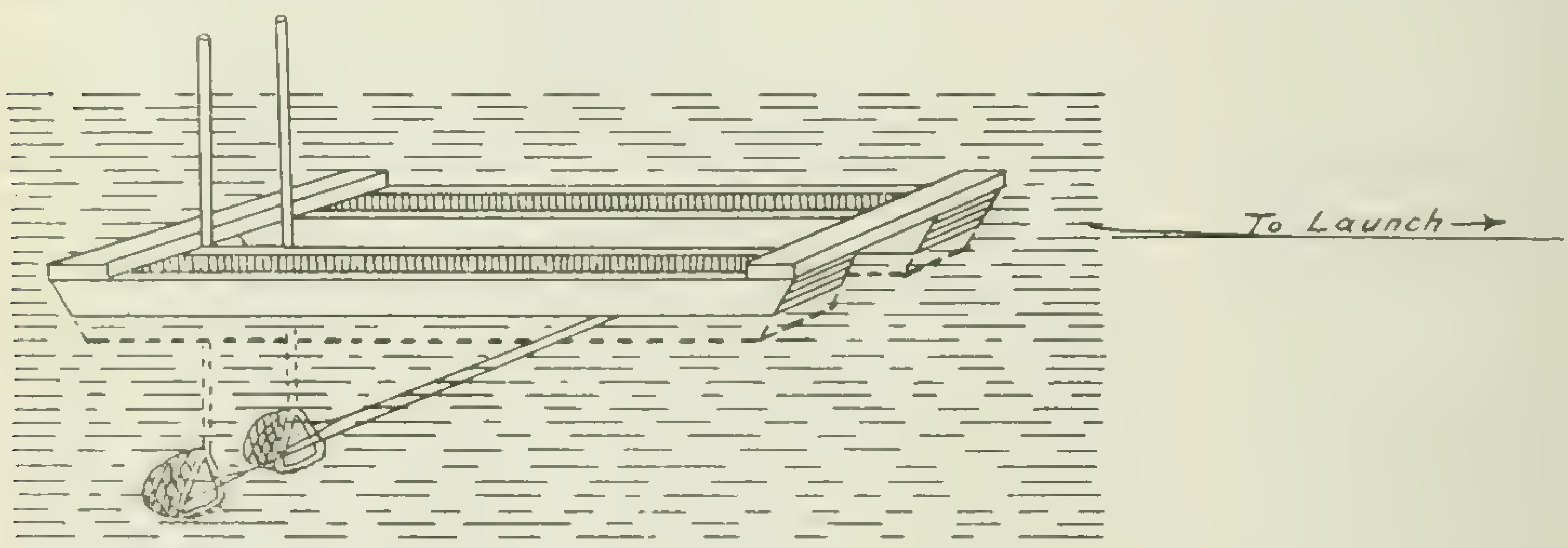

Fig. 1.

In order to remove the mussels from their shells they are subjected to boiling in water. This kills the animal, causes the relaxation of the powerful adductor muscles, which hold the valves together, and permits the easy removal of the muscles from their attachment on the valves. The boiling pans vary in size, but are usually about 6 feet long by 4 feet wide and 8 inches deep.

The bed near Morgan's island is about ½ mile long and 50 feet wide. Here the bottom is gravelly, and although the shells are numerous and of good quality, the number of dead ones is considerably larger than farther down the river, where the bottom is muddy.

Last year the shelling was done below the town at a point a mile north of Port Maitland. Here 265 tons were taken from an area less than ¾ of a mile in length. The bed, I am told, showed no signs of depletion. This year the fishing has been done above the town, and although about 260 tons have been taken, the ground is apparently not as productive as was anticipated.

PEARLS.

A considerable number of pearls and slugs are also found. Some are of very fair size and good quality. In Mr. Clark's opinion, pearling alone would insure a sufficient return for one's labours if followed up. The highest figure yet obtained for a pearl was $75.

RECOMMENDATIONS.

In order to develop to the fullest extent the resources of the river, three main steps are urgent; first, to insure against depletion of the present stock of clams; second, to restock and stock artificially all favourable areas, and third, to improve the river in general by stream regulation. Since the last-mentioned object is so fundamental, I shall deal with it first.

STREAM REGULATION AND SOME OF ITS ADVANTAGES.

Through the progressive removal of the natural physical conditions regulating stream-flow, the floods in the river have for some years been becoming more and more violent and destructive. This increased flood-flow has naturally reduced the volume of low water-flow proportionately. These two conditions, along with the scouring and general damage of river-bed, constitute an increasing menace to mussel life, to fisheries, and to power development along the river.

Some idea of the truth of the above statements may be deduced from a study of the following table of volume of flow at different points. The maximum flow of greatest recent flood is also included. This took place in the spring of 1912.

APPROXIMATE flow in cubic feet per second, period 1914, 1915 and 1916.

Grand River Stations.	Maximum.*	Minimum.*	Mean.	Drainage area in sq. miles.	1912 Estimated Maximum.
Belwood	4,600	3	190	280	10,000
Conestogo	9,300	15	375	550	20,000
Galt	19,000	55	810	1,360	50,000
Glenmorris	23,000	70	900	1,390	...
Brantford	26,000	100	14,000	2,000	100,000
York	27,000	200	1,550	2,280	...

* Maximum flows are mean of two gauge heights, taken a.m. and p.m. daily. Minimum flows in some stations consist of leakage from dams.

The danger consequent upon these conditions cannot readily be overestimated. The fact that drainage areas of the Grand River and Great Miami river flowing through Dayton, Ohio, are approximately equal, is sufficient proof. No doubt far-reaching measures for the prevention of dangerous floods will have to be taken in the future. If such measures involve water conservation, the resources of the river will be enormously increased.

In the fall of 1912 the Hydro-electric Power Commission made a reconnaissance survey of the river watershed covering the main stream from Caledonia to the headwaters; also of the larger tributaries from their confluence with the main stream to their headwaters. In this survey, the main object of which was to ascertain what locations, if any, merited examination as sites for storage reservoirs and regulating works, it was found that by the building of nine dams ranging from 30 to 65 feet, storage reservoirs ranging from 450 acres to 3,000 acres in area could be obtained; the aggregate acreage being between ten and eleven thousand. While the above figures

are approximations, it is believed to be reasonably certain that the system of storage basins would have an aggregate impounding capacity of not less than five billion cubic feet.[1] It will be evident that the economic advantage accruing from such pools of dependable character cannot be lightly esteemed. In relation to mussel life there would be not only the addition of new flood areas, but also no doubt the improvement of the bed of the streams back of these areas. In these lake-approximations, or river-lakes as they have been called, admirable conditions should be afforded for the particularly valuable shell *L. luteola*. Not only does this shell work up well into buttons but it also lends itself readily to artificial propagation on a commercial basis. Although it is rare to find shells of commercial value in lakes, these river-lakes form a natural habitat for the above mentioned mussel. For example, Lake Peoria, a lake expansion in the Illinois R. forms at present probably the best mussel producing district in the United States. As the young mussels are parasitic on fish in the early stage of their life history, it would of course be necessary to construct effective fish-ways at these dams.

Further, by a study of tables 1 and 2 it will be seen that there are considerable stretches in the river where apparently suitable mussel areas obtain. If mussels are not found here in a survey, the fault will probably be due to flood conditions prohibiting their development in these areas. If such is the case, flow-regulation should overcome the unfavourable environment.

FOOD, A FACTOR OF THE ENVIRONMENT.

In the discussion of favourable environments, due consideration must be given to the food problem. This is doubtless the most important factor in the environment of the mussel, and it is unfortunate that no extensive work has been done along this line. Actual records of stomach contents of fresh-water mussels are rare. Records of analysis show that among the microscopic forms, minute plants, diatomaceæ and other algæ, constitute a part of the food of the mussels. With reference to the food habits, Professor Clark and Dr. Wilson report in part, as follows: "The stomach contents of mussels taken from the main current of the St. Mary's, St. Joseph, and Maumee rivers were rather noteworthy for their paucity of organic material. Through the large mass of muddy matrix filling the stomach were usually scattered a few *Scenedesmus*, various diatoms, and an occasional *Pediastrum* or *Cosmarium*." Dr. Petersen, a Danish ecologist and Director of the Danish Biological Station, has fully demonstrated that the fine dust-like detritus forming a thin top layer of bottom deposits constitutes a large part of the food of the oyster and other mollusks. Dr. Jensen, Petersen's colleague, concluded after investigating the source of the detritus that its origin is primarily from sea plants, broken down until it assumes the fine dust like form. It has been suggested[2] that the "large mass of muddy matrix" referred to by Clark and Wilson was probably the kind of material described by Petersen as "dust-fine detritus." Although large bivalves may not be able to avail themselves of the layer of dust-fine detritus, it is no doubt taken in by water currents. Dr. Jensen also examined the water by centrifuging, and obtained material identical with the top layer of bottom deposits. In Oneida lake the surface of the bottom deposits, in bays and quiet bodies of water, is reported to be of precisely the character described by Dr. Petersen. It would, indeed, be very interesting to establish the relationship between stomach-contents of different species of mussels and the nature of the river bed in which they do, or do not thrive. It would, no doubt, lead to valuable information with regard to the choice and the establishment of new areas for their development. It may be found that the food

[1] Sixth Annual Report, Hydro-Electric Power Commission of Ontario, 1916.

[2] Relation of Mollusks to Fish in Oneida Lake, by Frank Collins Baker, University of Syracuse, N.Y., July, 1916.

supply of the mussels is by no means fully dependent on the free-swimming organisms, and that the favourable localities, discussed above, are largely conducive to the development of the mussel on account of conditions favouring the deposition of the "detritus."

RESTOCKING AND STOCKING.

The restocking of areas where mussels at present exist, and where active fishing is going on, and the stocking of new areas, may be summed up under the head of artificial propagation. As the method pursued in artificial propagation has been described in a general way, we shall now consider its application to the river in question.

Of all mussels so far experimented with, *L. luteola* lends itself most readily to artificial propagation on a commercial basis. It is the species chiefly propagated at present by the United States Government. As time and opportunity prevented my making an extensive survey of Grand River, I cannot state the extent to which this species occurs therein. It is, nevertheless, very generally distributed in Ontario waters, but in order to attain to a size and abundance suitable for commercial value it apparently must have the conditions more or less as described above in "river-lakes." The specimens so far obtained from the river are not of very good quality. This is probably due to unfavourable conditions preventing their optimum development in the areas from which they come. In a commercial appraisal made of some of our shells by Mr. John B. Southall, Shell Expert at the Fairport Station, this particular shell was reported on as follows:[1] "medium size, no discoloration, brittle, third grade[2] and yielding 788, 16—line,[3] gross blanks per ton." In his remarks he further states that they were rather thin and of a steel-coloured nacre and produced blanks that would chip and cleave during the processes of button manufacture.

With regard to this mussel I would suggest a careful examination of the areas lying behind the larger dams with a view to stocking them with the valuable species. Such a survey might include the dams at Dunville, Caledonia, Brantford and Galt on the main river, and also the larger ones on the Speed tributary, where the fall is well utilized, and where clams of good size are said to be found in all such storage basins as hold back water over a considerable area. Behind the dam at Caledonia there is a stretch of practically dead water for twenty miles which might lend itself favourably to the development of this mussel. Here the river bed can be classed as permanent, inasmuch as the usual freshet velocity of the river water above is greatly reduced on reaching this point. At Brantford the old barge canal, described above, containing also Mohawk lake, might prove a very suitable locality for propagation on a small scale. For the purpose of stocking, I would strongly recommend that an attempt be made to introduce the particularly fine *luteolas* of lake Pepin, in the Mississipi, about 30 miles down the river from St. Paul, Minn. In the United States gravid mussels, for purposes of infection, have not been shipped over a much greater distance than 300 miles, but I am informed by the Director of the Fairport Station that they sent a couple of shipments of live mussels from Fairport to New York in the fall of 1916, and that the majority reached their destination in good condition. The distance from lake Pepin to Galt, Ont., would be about 835 miles by rail.

Fortunately, this species is not very exclusive in its choice of hosts, neither is its spawning period of short duration, as is the case with some other commercial mussels. All the Lampsilinæ, in fact, are gravid, more or less, during the whole year

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1 In the report of the appraisal the *luteolas* sent from the Canada Co. Cut and from the Grand River were combined in one report.

2 In grading the material I sent him, the texture and lustre of the niggerhead (*Q. ebenus*) was taken as the standard.

3 A line in button measurement is 1/40 of an inch.

but most ripe ones are found from April to July. In my survey in August I found quite a number of gravid *luteolas* but none that on microscopic examination proved to be ripe. This early and extended spawning period would be favourable to successful shipping, before the warm weather comes on. The fish that may serve as carriers belong mainly to the families Centrarchidæ and Percidæ. The species are: *P. sparoides* (speckled bass); *P. annularis* (crappie); *L. pallidus* (blue sunfish); *M. salmoides* (large-mouthed black bass); *M. dolomieu* (small-mouthed black bass); *S. vitreum* (yellow pickerel); *S. Canadense* (sand pickerel); *P.flavescens* (yellow perch) and *R. chrysops* (white bass), all well represented in our waters.

Since the artificial propagation of this mussel is past the experimental stage, I did not consider it advisable to repeat the operation here, on my return from Fairport, particularly as my time was limited and as the localities visited did not appear very favourable. It was kindly suggested at Fairport that gravid mussels be shipped over here for infecting purposes.

Lampsilis recta, though not found plentifully in the Grand river, is a very valuable shell on account of its fine quality. Mr. Southall reported it to be of large size, without discolouration, firm and of first grade, making 369, 16 -line and 470, 24—line gross blanks per ton. Although the usual run of this species is coloured, those from the Dunnville area seem to be of fine quality. There are, however, some shells which show discoloration. In the fiscal year 1916, 11,288,300 larval mussels of this species were planted at Fairport. The fish which may serve as hosts for artificial propagation are: *L. pallidus* (blue sunfish) and *A. cyanellus* (green sunfish). The former of these species occurs abundantly in some parts of lake Ontario and lake Erie and their tributaries, but the latter has not been reported from Ontario, although it is supposed that it will be found in lake Erie. *P. annularis* (crappie, also called silver bass) has been found naturally infected with this mussel, but it is rare in our waters.[1]

The spawning period of this mussel is similar to that of *Lampsilis luteola* and the river appears to be adapted to this species. The shellers at Dunnville seem to prize this shell above all others.

Lampsilis ventricosa.—This shell is not used very extensively in button manufacture, but it is worked up into novelties. Large shells, however, make buttons of good lustre. Last year 447,000 glochidia were used for infection at Fairport. The species of fish that may serve as hosts in artificial propagation are: *P. annularis, L. pallidus,* and *M. salmoides* (large-mouthed black bass). At present it would not appear to be essential to increase the stock of this shell.

The *Quadrula* group is well represented in the Grand, but only two species appear in large quantities—*Q. plicata* and *Q. undulata.* These constitute at present our chief button shells, and the Canadian Pearl Button Company, of Trenton, Ont., which has the sole right to the Dunnville fishery at present, reports that the shells from the Grand compare favourably with those shipped to their plant from the United States. In the commercial appraisal of these two species from the Grand, the report is as follows:—

Species.	Common Name.	Size.	Dis-colouration.	Texture.	Grade.	No. of gross blanks per ton	
						16-line.	24-line.
Q. plicata[2]	Bluepoint	Large	None	Firm	3rd	142	245
Q. undulata	Three-ridge	Large	None	Firm	3rd	182	214

[1] Manual of Vertebrates of Ontario, by C. W. Nash, has been consulted for fish distribution in our waters.

[2] The *plicata* from Mud Creek, near Port Franks, were evidently grouped with those of the Grand river, for there is but a single report.

It is noted that they had a very uneven inner surface, causing waste in cutting blanks; the tips of the shells were too thin for buttons. The colour and nacre were not as bright as the usual run of the species found in the Mississippi river; but it nevertheless makes a good button and, with proper care, the material could be worked up with profit. As the Button Company of Trenton works up tons and tons of these shells their statement as to the comparative value of the shells must also receive due consideration.

With regard to the propagation of the former species (*Q. plicata*), Dr. Howard, of Fairport, Iowa, makes the following statement:—

> "Several factors favour the artificial propagation of this species upon a practical scale. It is common and at present one of the most used shells in the button industry. It seems to be a form not narrowly restricted as to hosts, and these are indicated to be among the commonest and most readily obtainable fishes. Although a river form, its habit as a dweller in stiller water and on mud bottom makes it susceptible to propagation or control under conditions readily imitable in artificial lakes or ponds. A continuous water supply is desirable; my observation has been, however, that it will survive rather adverse conditions in this respect. I have collected many live specimens from a slough which had gone dry to the extent that only mud remained. Under these conditions the majority of the pond mussels, *Anodonta corpulenta,* had died. I would cite also the finding of this species accidentally introduced in the parasitic stage into an artificial pond at Fairport, Iowa. The pond had gone dry, and I found a specimen still alive buried in mud barely moist. It is evident, I think, from these observations that the species is hardy, at least as regards some of the more common vicissitudes to which mussels are naturally subjected."[1]

In his experimental work with this species he found that *P. annularis* (crappie), *P. sparoides* (speckled bass), *P. flavescens* (yellow perch), and *L. pallidus* (blue sunfish) were successful carriers. The spawning period is short, being confined chiefly to the month of July. In the last fiscal year 147,000 glochidia of this species were set free in the parasitic stage at Fairport.

At present the safe-guarding of the beds against depletion is more urgent than experimental work in artificial propagation of this species. As experience and equipment are obtained, work on the more difficult *Quadrulas* should no doubt be proceeded with.

I have so far not obtained any data of experimental work done on *Q. undulata.* In general appearance the two forms are similar. In *plicata*, the umbones are more elevated and inflated than in *undulata.*

PROTECTION OF FRESH-WATER MUSSELS.

For the protection of the present mussel beds the following methods may be considered of sufficient importance to merit discussion.[2]

(*a*) A closed season in each year.
(*b*) Restriction as to the methods of fishing.
(*c*) Restriction as to size of mussels retained by fishermen.
(*d*) Closed regions for specified number of years.
(*e*) The imposition of licenses.

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[1] Experiments in propagation of Fresh Water Mussels of the Quadrula group. By Dr. A. D. Howard, Bureau of Fisheries, Document No. 801.

[2] See also, Protection of Fresh Water Mussels, by R. E. Coker, Ph.D., Bureau of Fisheries, Document No. 793.

(*a*) The main object to be attained by instituting a closed season for fishing is the protection of the beds during the breeding season. Incidentally, however, a second benefit naturally accompanies the one sought, for by limiting the length of the season, the extent of the fishing will likewise be diminished. Since the chief commercial shells so far shipped are *Quadrula plicata* and *undulata*, and since these species have short periods of gravidity during the summer months, the closed season restriction peculiarly applies to the Grand. But the river also supports other shells of some commercial value which have long breeding seasons, and thus the protection afforded would not be sufficiently wide-reaching. This will be particularly true in case of artificial propagation. Besides, an interruption of fishing operations during a few summer months would seriously interfere with the industry.

(*b*) At present the shells are obtained in one way only, as described above. This method is fortunately not the one against which complaints are generally made. Although it roots up the bed it does not unnecessarily injure the mussels which are too small for commercial purposes, and these should be returned to the water.

(*c*) It is obvious that there is a limit to the size of a shell beneath which it is pure wastefulness to retain it. The fishermen and the button manufacturers lose time in handling the material and the beds are depleted at a much greater rate than they would otherwise be for the same finished product. A limit for every species is, as a rule, impracticable if for no other reason, at least for the fact that the determination of species is sometimes difficult. After a size limit has been decided upon, considerable details will have to be worked out in order to satisfactorily enforce any regulations agreed upon.

(*d*) One of the most immediate protective measures is that of closed areas. This best meets the case of the long breeding species and gives them an opportunity to restock areas, preventing for a term of years the disturbance of gravid clams some of which, when disturbed, discharge the young even though not mature. It also favours the building up of beds by allowing the young clams to establish themselves. The system on which a river or portions of it are to be closed, and the time and duration of areas closed can best be determined by studying field and biological conditions.

(*e*) By the granting of fishing permits as at present on the Grand, no doubt the number of shellers is thereby limited. It is a question, however, just how far the interests of a private person or firm are safeguarded as well as those of the fishing grounds. Although such a fishing permit was granted with a view to stimulating shell prospecting it nevertheless undoubtedly discriminates against other persons or firms. If fishing licenses were granted to resident fishers, thereby eliminating the exploiters or such persons as would not wish to follow up the industry, no doubt good results would be obtained. This would also leave to fishers the opportunity to sell to such firms as paid the best prices.

RIVER AUX SABLES.

In the brief survey of this river for shells I confined my attention chiefly to its lower stretches from which reports of abundance of shells had come in.

The east branch of the river rises a short distance north of Jaffa, in the township of Hibbert, county of Perth. The west branch has its course several miles to the west of this point and the two branches unite near the northern boundary of Stephen township. After a course of about 90 miles the river enters Lake Huron at a point 12 miles, almost due west, from the confluence of the two branches. This U-shaped river is remarkable for its meandering course and for its apparently recent geological history.

Until about 25 years ago the river outlet was not as now, but at a distance of 10 miles further south, near the village of Port Franks. It is an artificial channel

one-quarter of a mile in length. Previous to this cut the river made an abrupt turn at Grand Bend when within one-quarter of a mile from the lake, and it flowed almost parallel to the lake shore to the natural outlet, below Port Franks. This deviation of its course was probably due to the sand collecting near its northwesterly banks, forcing the river southwards.

Owing to the frequently occurring floods on the lowlands, the Canada Company, which owns extensive tracks of land in the district, decided to make a cut from the northwestward flowing arm of the river to the southward arm. I shall refer to it as the "Canada Company Cut." It passes through the former lake Burwell and is 3.5 miles in length. Later on, wishing to further improve their lands, the Company put the second cut through at Grand Bend, diverting the river directly into the lake. Although the upper part of the old river channel, between Grand Bend and the lower cut is dry, it still contains a large volume of water. It approximates, in fact, to a narrow lake about 8 miles in length. In places it is a few hundred feet wide and quite deep. The greatest depth at which I took soundings was 17 feet. A fair and apparently continuous current of water flows from it into the main stream at the cut.

Previous to the construction of the artificial channels the river must have been admirably suited to the support of mussel life. Even when the second cut was put in at Grand Bend, and the water let off, I am told by an old resident, Mr. Brenner, that the bed was paved with shells for a considerable distance, many of these being of very large size.

On ascending the river for a few miles from Grand Bend we found large numbers of good-sized clam shells lying on the banks, evidently thrown up in dredging the bed after the cut had been made. In the river we also found quite a number of large mussels of commercial value, the species *Q. undulata* predominating. Other species found were *L. luteola, L. ventricosa,* the large but useless *A. grandis,* and a dead *S. costata.* These mussels were lying about on the bed of the river, in water about a foot deep. With the small amount of water flowing it is difficult to understand how such a quantity of mussels of good size could be maintained. Hand picking here would yield a fair quantity of commercial shells, but since the river is small the supply would soon be exhausted. From Grand Bend we went to Port Franks and crossing the Canada Co. Cut near its western terminus, investigated the water for clams. We found a small bed near the bridge, in shallow water, somewhat protected from the main current. Many of the shells were of large size and also represented quite a variety of species:—*L. recta, L. centricosa, L. luteola, Q. undulata, Q. rubiginosa,* and *S. costata.* In the commercial appraisal the *uteolas*, sent from this locality, were reported on in conjunction with those from the Grand so that I cannot state precisely what their grade is. We found *L. recta* 6 inches in length and of very fine quality. It was gratifying to find such a collection of shells in an artificial waterway, At Port Franks I was told that the vicinity contained "oceans of shells." As I was not yet acquainted with the river bed, I hoped for good things from it, thinking I might find a suitable area for *L. luteola.*

As stated above, this old channel constitutes a rather long narrow lake from which a small stream of water flows. The bottom of this bed is in many places densely covered with aquatic vegetation, *Chara* predominating. The shores are usually either steep or marshy. Large clams in considerable quantities were found in the shallow water along the shore, where they appear to be somewhat generally distributed. The commonest species is *Q. undulata,* although the Lampsilis group is also represented. I also found one *Q. rubignosa.* I found it to be practically impossible to determine the extent of the mussel life beyond a short distance from shore, except in very deep parts, and in the upper stretches where quite large barren areas of compact bottom obtain. The small crow-foot bar which I had made for shell prospecting, proved in general absolutely valueless here on account of the dense mat of vegetation covering a large part of the river bed. With a good motor launch and a heavy dredge one might

settle the problem, but I do not consider the undertaking worth the trouble or expense. In the deeper parts of the river I was able to use the crow-foot bar but got no shells except dead ones. The river may at one time have contained large quantities of mussels but it seems too stagnant to make good clam beds possible. This condition also would promote the growth of the vegetation now so abundant.

Taking all conditions into consideration this area is of no value for mussel culture. The shells that are there are perhaps only a remnant of a once larger supply and may in time quite disappear. The *L. luteolas* found were fairly large but were badly stained and seemed unhealthy.

In order to make a careful survey of this locality I decided to further investigate the cut and work my way to the east branch of the river to prospect for shells there. The lower end of the cut is quite wide and approximates a small river, but we found no clams with the exception of the bed near the bridge mentioned above. I was able to determine that the upper part of the river's section between the cut and Grand Bend does contain the commercial shell *Q. undulata.* At one place where I went into the water to a depth of four or five feet, I found the bed to consist of fine clay mud quite thickly covered with mussels of this species. They were, however, rather smaller than usual.

This river seems to be peculiar in having a very irregular channel as to width and depth. At places it is shallow and narrow and then again it becomes wide and deep. Shells seem to be quite generally distributed. Even at Ailsa Craig, which must be over 40 miles up the river from the cut, we found the species *Q. undulata, L. ventricosa, L. luteola* and *Unio gibbosus.* They were not plentiful and of rather small size—too small to be of much value. Good beds of shells may be found on a more thorough investigation. In fact, I am inclined to think that the shells found lying in the shallow places near Grand Bend and in the Canada Company Cut may be washed down from native beds up stream from these points. Conditions in the lower stretches of the river seem to be very favourable to mussel development even with the small flow of water.

I also investigated the river near its mouth at Port Franks, but evidently there are no mussel beds of any importance there. No doubt the great quantities of sand carried down during floods do not permit their development.

It is singular that even small streams in this vicinity support mussels of commercial value. At the mouth of Mud creek, a small stream near Port Franks, I found a number of *Q. undulata* of fairly good size. *Q. rubiginosa* and small *luteolas* were also found here. Shells are reported to be plentiful further up this creek.

In the vicinity of Grand Bend and Port Franks a considerable quantity of shells should be obtainable by hand picking at low water. As the areas are not large, however, the supply would soon be exhausted. Since $20 per ton, delivered at the station, has been offered for them, some enterprising man might find his labours well repaid.

I should advise that the river above the Canada Company Cut be examined with a view to determining its resources in mussel life.

POINT EDWARD.

On my arrival at the bay at Point Edward, near Sarnia, I was again several times assured of the abundance of shells by men about the lumber yards. I obtained a row-boat from the Spanish River Lumber Company, and crossed the North bay (north of the Cleveland lumber tramway) in search of shells. The water here has an average depth of about 3·5 feet and the shells are therefore readily obtained with a dip net or by wading. The sandy bottom is free of weeds with the exception of the margins near the marshy borders. As the water was clear I could readily see the bottom. I found only small shells such as we find in any of our fresh water lakes, for example

small worthless *luteolas*. Not having completely satisfied myself I again went over the ground thoroughly the next day in company with Captain Glass of Sarnia, finding very little, however, of any value whatever. The current flowing through the river here is very strong. It seemed foolish to look so carefully for shells large enough and in sufficient quantity to be of commercial value, but I desired to thoroughly settle the matter. Popular reports concerning shells are generally misleading. This is due to the fact that very few people understand shells from a commercial point of view. With regard to lake Smith, for example, glowing reports of shells were made. One man supporting this view was kind enough to get a boat and take me over the ground, but we found only numerous specimens of the common worthless lake clams.

NOTTAWASAGA RIVER.

Mr. Gross, button-manufacturer of Kitchener, Ont., had been informed that large quantities of mussels had been found along the river. He decided to investigate the reports and agreed to my accompanying him. A motor launch was engaged to take us up the river. Several miles up the river we discovered a bed where the mussels were very thick. We needed but to drag the crow-foot bar a short distance when a considerable number of clams would be caught. Shells were also obtained in a similar manner near the mouth of the river, just out from the Riveria hotel. In all, the following species were taken: *L. recta, L. ventricosa, U. gibbosus, S. costata,* and *S. edentulus.* In the commercial appraisal the *L. ventricosa* are reported to be small, no discoloration, hard and brittle, fourth grade, and giving 610 16-line gross blanks per ton. Many of the *ventricosa* taken were too small to be of commercial value and had to be thrown back. The shells here are very remarkable for their colour. *Ventricosa* is in fact the only species showing no discoloration. Some of the *recta* are extremely dark purple. Mr. Gross did not consider it worth while to prospect further. Only a small part of the river has thus been surveyed for shells. The prospect here is not at all promising, at any rate not until there is a demand for coloured shells. It would be interesting to determine the cause of discoloration. This is as yet unknown.

The bottom, from which most of the shells came, was gravelly and the water from 5 to 6 feet deep. There is a large flow here and the river should support considerable mussel life.

GENERAL REMARKS.

This investigation was conducted only at selected points on a few of our rivers. The results cannot, therefore, be taken as finally indicative of our mussel resources. The river Thames, for example, draining a large area between the Grand and the Aux Sables, both of which contain commercial shells, has not been touched. It is impossible to know our resources until a more extended survey is made.

A great deal of important information could no doubt be obtained quite economically if further fresh-water mussel investigations were combined with those of the district hydrographers of the Hydro-electric Power Commission of Ontario. They, I believe, cover a great many points along our rivers regularly. In the month of June of last year the staff at Brantford visited the following stations:—

Stations.	*Streams.*
Burford,	Whiteman's Creek,
Onondaga,	Fairchild's Creek,
Brantford,	Grand River,
Canning,	Nith River,
Nicholson,	Nottawasaga River,
Glenmorris,	Grand River,

Stations.	*Streams.*
Galt,	Grand River,
Kimberley,	Beaver River,
Hespeler,	Speed River,
Markdale,	Rocky Saugeen River,
Hornings Mills,	Pine River,
Welland Canal,	Welland River,
Owen Sound,	Sydenham River,
Meaford,	Big Head River,
York,	Grand River,
Severn,	Severn River,
Washago,	Black River,
Port Elgin,	Saugeen River,
Walkerton,	Saugeen River,
Salem,	Irwine,
Belwood, Conestogo and St. Jacobs,	Grand and Conestogo Rivers,
Carahers,	Speed River,
Kilworth, Fenshaw, Ealing, Kimberley,	Thames, three branches,
Arkona,	Aux Sables River.

In the present year a good many other stations will probably be added. With a car at their disposal the points could be readily reached and often much time saved.

The investigation might also be extended beyond the province of Ontario. The St. John river, N.B., has a large area that may possibly be suitable for mussel culture. Ten miles above Fredericton the Keswick stream enters from the north, and below this point the bed is literally choked with alluvial islands. At Sugar island, the largest of the group, the river measures 2·5 miles from bank to bank. From Fredericton to Gagetown, a distance of 34 miles, the surrounding land is very low. On the east a mere alluvial flat of great extent separates the waters of the St. John from those of the Jemseg. Some farmers here obtain annually a crop of fish and vgetables.[1] A few of the upper sinuses that branch off to the east from the river might also be suitable for clams. One would not expect to find our larger species there now, but it does not necessarily follow that they would not thrive if introduced. The greatest difficulty would probably be found in procuring the proper species of fish to act as hosts. Here it may be mentioned that in the flood areas of the Mississippi many fish, cut off from the river when the flood subsides, are caught, infected and liberated again. In this way the double purpose of restocking the river with clams and reclaiming the fish is served.

In Manitoba there seems to have been an immigration from the upper waters of the Mississippi region. I am informed that in the *Journal of Conchology* (Leeds, Eng.) IV., pp. 339-346, 1885, there is an interesting account of the Mollusca of Manitoba by R. M. Christy. In a letter received from Dr. Bryant Walker, Detroit, Mich., relative to this article, it is stated that the author (Mr. Christy) lists nineteen species of which six are unidentified. They are: *L. recta, radiata, luteola, borealis,* and *alata. Q. rubiginosa, plicata, lachrymosa,* (and *asperima*), *undulata* and *heros. Symp. complanata; Stroph. edentula.* Mussels in that region were abundant and especially in the Shell river, which runs into the Assiniboine from the east, about fifty miles above its junction with the Qu'Appelle. Hundreds of dead shells belonging to many species occurred.

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[1] The St. John River. Dr. W. Bailey.

Dr. Walker obtained through the Am. Mus. of Nat. Hist. of N.Y., the following species from the Assiniboine: *Lamp. recta, ventricosa, luteola,* and *alata; Sym. complanata; An. grandis* and *Quad. undulata, lachrymosa* and *rubiginosa.*

Many species of commercial mussels are thus represented in our western waters.

Finally, since the maintenance of a mussel supply depends on our fresh-water fish supply, it will be necessary to direct our attention to the greater and more important problem of fish conservation. It is obvious that the two problems go hand in hand, and a station set aside for the latter should be supplemented by a department working in the interests of the former wherever the conditions of the surrounding country demand it. Fish ponds in which the proper species of fish could be reared for the purposes of infection and experiment, might at the same time yield valuable information in the interests of fish-culture. Such information would be of the greatest importance in hastening the day when the farmer would raise his fish as naturally as he raises his poultry. In the near future fresh-water research laboratories, in which our fishery problems are scientifically worked out, will have to be established. But our inland fishery problems can never be satisfactorily solved until the still more basic problem of water conservation is seriously dealt with. Of all the problems relative to national economy none is more likely to engage our serious attention in the future than that of water conservation.

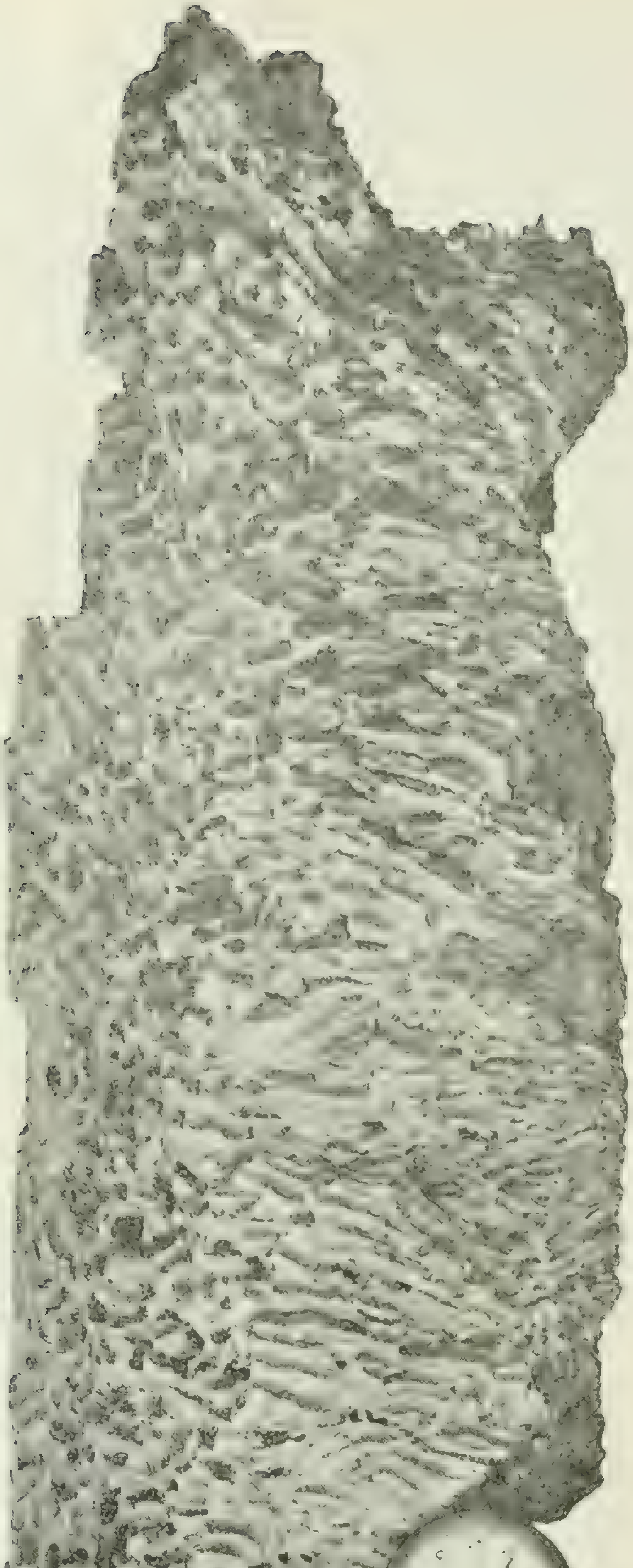

Fig. 1.—Wood bored by *Teredo navalis* at Charlottetown, P.E.I., within a period of sixteen months.

IV

NOTES ON THE HABITS AND DISTRIBUTION OF TEREDO NAVALIS ON THE ATLANTIC COAST OF CANADA.[1]

By E. M. Kindle, Ph. D., etc.

INTRODUCTION.

A specimen of the boring work of the "ship worm," *T. navalis* was recently presented to the Museum of the Canadian Geological Survey by Mr. H. E. Miller, accompanied by notes showing the dates within which the destructive work had been accomplished. Although a considerable literature exists on the destructive work of Teredo, records of its habits and work in Canadian waters are sufficiently scarce to justify recording some of the interesting facts which have been communicated to the writer by Mr. H. E. Miller. In the course of his work as an engineer in the Department of Public Works in renewing wharves, piling, and other seashore structures in Prince Edward Island, Mr. Miller has had unusual opportunities to become acquainted with the work of the Teredo. The data relating to the habits of the boring mollusc, popularly known as the ship worm, which are recorded in this paper have been supplied chiefly by Mr. Miller.

The distribution of *Teredo navalis* presents some novel features. It affords an example of discontinuous distribution which parallels that of the common oyster in Canadian waters. It is associated with the gulf of St. Lawrence colony of the Acadian fauna, but its distribution varies rather widely, as will be pointed out, from that of some of the other species of this northern Acadian colony.

HABITS.

Considerable human interest attaches to the boring work of the mollusc, *Teredo navalis*, because it is equally capable of destroying wharves, or railway bridges, or sinking ships when precautions to check its ravages are neglected. The depredations of Teredo are not confined to any particular parts of the world's coast lines. Its work is well known on the Pacific coast, where the Isopod, *Limnoria tenebrans*, is locally even more destructive.[2] In Europe the extraordinary increase in the numbers and abundance of Teredo at various widely separated periods have several times brought it into very prominent notice. During one of these periodic increases in its numbers —about 1730-32—Holland was imperilled by the threatened destruction of its sea dykes.[3]

The rapidity with which timbers are frequently destroyed by *Teredo navalis* is shown by the accompanying photograph (fig. 1) of a portion of a beech timber which was 12 inches square when placed in the water. The timber was perfectly sound when placed in the tidal zóne just west of the entrance to Charlottetown harbour, Prince Edward Island. The completely honeycombed condition shown in the figure was accomplished in a period of sixteen months. This is a much more rapid rate of

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1 Published with the permission of the Director of the Geological Survey.

2 Harrington, N. R., and Griffin, B. B. Notes on the distribution and habits of some Puget Sound Invertebrates. Trans., N.Y. Acad. Sci., 1897, pp. 158-9.

3 Van Baumhauer, F. H.—The Teredo and its Depredations (translated from Archives of Holland, Vol. I). Popular Science Monthly, Vol. XIII, 1878, pp. 400-410, 545-558.

destruction than has been ascribed to its ally *Limnoria lignorum*, which Murphy[1] states can, when abundant, destroy soft timber at the rate of half an inch or more every year. Stearns[2] has recorded two interesting examples of the work of Teredo. He states that "upon the seafront of San Francisco I have known piles of Oregon pine and fir over a foot in diameter rendered worthless in eighteen months." Dr. Dall is quoted by Stearns as having noted a case of the destruction of the supports of a small pier made of piles 6 to 8 inches in diameter near the entrance to Chesapeake bay in six weeks. Prof. A. E. Verrill writes that "*T. navalis* is very abundant and destructive on the southern coast of New England. At my summer home on an island near New Haven it will reduce 2-inch planks and 4-inch stakes to a honeycomb condition in one season—1st July to September—as I have often proved by experience."[3] Although only a very thin film of wood separates the innumerable burrows, they in no case intersect or cut into each other.

The time of year at which timber is cut, according to Mr. Miller, is an important factor in determining the extent to which it is subject to or immune from the ravages of the Teredo. "Trees cut during the months from October to January give much greater resistance or are less attractive to the Teredo than the trees cut from February to May. The Teredo is practically inactive during the cold of winter."

One of the peculiarities of the boring habits of Teredo is its aversion to boring from one timber to another, no matter how firmly attached and adjusted they may be. "Over a shipbuilding experience of fifty years our general foreman of works, Mr. John White, observed only two cases where worms had worked from the hull planking into the timbers of vessels.

"Spawning time appears to be about July. Vessels launched in spring and hauled out before July, and those launched in October are practically free of the Teredo; those exposed during the latter part of June and during July, if not protected, being very freely attacked."

"To a great extent the Teredo will attack unprotected vessel hulls as freely as fixed timber, particularly if remaining idle for any length of time. Constant motion through the water, however, appears to hamper the attachment of the spawn to some little extent. Such protection, however, as tarring, copper or marine painting and creosoting proves an effective measure as long as the protecting agent remains intact."

"The point of entry of the borer spawn into the timber is below half-tide mark. A peculiarity is that standing timbers show a severed condition (very much after the fashion produced by the beaver), at from one to two feet above low-water spring tide mark in localities where spring tides have a range of 9 to 11 feet. From this point down the borers work entirely within the timber, not passing the line of the bottom, where this is muddy, but not having the same objection to sand, as shown by the specimen forwarded."

"Mr. Crandall, of the Crandall Engineering Concern, Boston, Mass., has made the statement to me, that if timber could be kept covered with a film of mud, it would be kept immune through the entry of Teredo spawn being prevented. Certain it is, that all other things being equal (particularly temperature and saltiness) the Teredo is much more prevalent and destructive where the surrounding shore and bottom is sandy. In twenty years' experience this office has never observed a creosoted stick affected by the Teredo. The impregnation used is fourteen and sixteen pounds to the cubic foot."[4]

A small amount of creosote appears to be not very effective, since Stearns states that at Christiania, where the Teredo is very destructive, he was told that "all the

[1] Proc. and Trans. N.S., Inst. Nat. Sci., Vol. V, 1881, p. 365.

[2] Stearns, R. E. C.—The Teredo or Ship-worm. American Naturalist, Vol. XX, 1886, pp. 134-135.

[3] Verrill, A. E. Letter to the author, February 21, 1917.

[4] Letter from H. E. Miller, to the author.

piles had been creosoted (ten pounds to the square foot) before they were driven in, but not to much purpose."[1]

The palmento of the southern states and some of the Australian woods are said to be immune from the attacks of Teredo. The papers by Putnam[2] and Cunningham[3] contain much information on the habits of Teredo.

An Icelandic naturalist[4] has made some interesting observations and experiments on the habits and biological characteristics of *Teredo norvegica*, the species found on the southern and western coasts of Iceland. Mr. Frits Johansen has kindly furnished the following translation and summary of these from the Danish: "The propagating (spawning) season continues through the whole summer (April-August). No larvæ are found in the mantle-cavity or in the sea; but numerous very small ones (burrows 1mm. long 0·5mm. wide) are found in driftwood from Faxebugt (W. coast) at the end of July.

"The growing period is mostly limited to two years as shown by experiment: I kept some pieces of wood with Teredo taken from the false keel of a fishing boat and kept it in a shaded cool place; the animals remained alive ten days; but inside of two weeks all were dead. Kept in a temperature of 6° C. for two days they all froze stiff, but were alive when thawed out again. In fresh water they only lived two to three hours; three hours in half sea and half fresh water or in putrid sea water.

"It is mostly only on two places that ships are attacked; at the waterline and in the false keel (or if this is missing the lower part of the keel itself). That this keel part is attacked is because it is buried in the sand, when the ship is beached, and thus gets no paint or tar. The "waterline" part of the ship gets easily its protection of paint or tar scraped off when loading, anchoring, etc. Plank edges are first and most attacked.

"The Teredo avoids leaving the wood in which it bores. Hence from the false keel only a few had penetrated to the true keel, and the burrows avoided the outer surface of the false keel. Where two parts of the false keel joined, the burrows never went through the contact but stopped short of a couple of inches. But how does the Teredo know when to stop burrowing? Maybe by sound-sense? In piers at Reykjavik, where *Limnoria lignorum* Ratk. burrows together with Teredo, one frequently sees that Limnoria eats away the woodparts surrounding the Teredo burrows and the calcareous lining of the Teredo burrows are exposed. Teredo therefore protects itself by thickening its calcerous lining 3 to 4 times the usual thickness by internal secretions.

"Boats on the water at the south and southwest coast are attacked by it.

"In later years it has been very numerous and destructive in sea-going ships belonging to the southwest coast; in many cases Teredo has been imported with ships bought in England, but some ships built in Iceland or lumber put into ships in Iceland have been attacked. Ships belonging to the north and northwest coasts (beached during the winter) seem to be free of Teredo. Maybe the many English ships bought and the unusually mild winter, and the fact that the ships are on the sea all winter are the causes of its frequency at the southwest coast for the last five or six years.

"The largest Teredo I have seen measured 27·5 cm. (to the base of the siphons) siphons ca. 2·5 cm.; average size of Teredo 16-18 cm., built in 1892."

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[1] *Ibid*, p. 135.

[2] Putnam, J. W.—The Preservation of Timber. Scientific American Supplement, Vol. X, No. 236, July 10, 1880, 3762-3763.

[3] Cunningham, J. T.—Teredo. Encyclopaedia Britannica, 9th Ed., Vol. XXIII, 1888, pp. 184-186.

[4] Saemundson, B. Zoolog. Meddel. fra Island (Zool. Notes from Iceland, p. 43, pp. 57-60). Vidmskab. Meddel. fra Naturhist. Foren. Kbhn. for Aared 1903 (Scientific papers from Natural History Society in Copenhagen for year 1903).

Bathymetric Range.

There is but little information on the depth to which Teredo can work below low tide level in Canadian waters beyond Murphy's[1] photograph of a piece of bored spruce which was submerged two years, four feet below low water at Pictou, N.S. At Woods Hole, Mass., it has been found living at a depth of 13 fathoms[2] and in New York harbour at 25 fathoms.[3] Three well-known rock and clay-boring molluscs are found in the same general region with *Teredo navalis.* These are:—

Petricola pholadiformis.
Zirfaea crispata.
Saxicava arctica.

P. pholadiformis appears to be most common near the inter-tidal zone, but it has been dredged at a depth of 30 fathoms in St. Marys bay by Dr. A. G. Huntsman. The recorded range of *Z. crispata* is from low tide to 70 fathoms in Canadian waters. Off the Maine coast it is recorded by Verrill[4] at from 22 to 44 fathoms. At Woods Hole it also occurs at a considerable depth below low tide. *Saxicava arctica* is another rock boring shell which has a considerable range below the tide line. On the Iceland coast it is found between tide marks[5] while off the Labrador coast it is common at 10 to 50 fathoms.[6]

Honeyman reported limestone boulders bored by Saxicava which were found at a depth of 65 fathoms off the Nova Scotia coast.[7]

The rock-boring habit gives to molluscs which practise it a special geological significance, as pointed out by Barrows.[8] The rock cells of such molluscs gradually expand as the rock is entered from the small aperture on the surface drilled by the very young shell into chambers corresponding to the size of the adult molluscs which thus leave no avenue of escape for the shell even after its death. The improbability of the removal of boring shells by current action to waters deeper or shallower than the living animal occupied permits the fossil molluscan rock-boring shells to yield information which is precise within the limits of their vertical range concerning the depth of the sea in which they lived.

DISTRIBUTION.

The genus Teredo has a wide distribution around the coasts of the North Atlantic. None of its several species however belong properly to the Boreal fauna although there are outlying colonies of some species which are surrounded by the boreal fauna. *T. norvegica*, which is the prevailing indigenous species on the eastern side of the North Atlantic, affords in its European distribution an interesting example of such discontinuous distribution toward the northern limits of its range. This species ranges through the Mediterranean and up the west coast of Europe into the waters of S.W. Norway. But G. O. Sars[9] states that "the only place inside of the Arctic

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1 Proc. and Trans. N.S. Inst. Nat. Sci., Vol. 5, 1881, p. 376, fig. 4.

2 Summer, F. B. Osburn, R.C., Cole, L. J. A Biological Survey of the Waters of Woods Hole and vicinity. Bur. of Fisheries, Bull. 1913, Vol. XXXI, Part II, Sec. III, p. 702.

3 Proc. and Trans. N.S. Inst. of Nat. Sci., Vol. V, 1881, p. 376, fig. 14.

4 Am. Jour. Sci., Vol. 7, 1874, p. 503.

5 Johansen, A. C. On the Mollusca between tide marks at the coasts of Iceland. Videnskabelige Middelelser fra den Naturhistoriske Foresig I. Kjobenhaon, 1902, p. 386.

6 Mem. Bos. Soc. Nat. Hist., Vol. I, p. 282.

7 Honeyman, Dr. D. Glacial Boulders of Our Fisheries and Invertebrates, Attached and Detached. Trans. Nova Scotian Institute of Natural Science, Vol. VIII, Part III (1888-89), p. 210.

8 Barrows, A. L. The Geologic Significance of Fossil Rock-Boring Animals (read before the Palæontological Society of America). Bull. Pal. Soc. Amer., Vol. 28, 1917

9 Mollusca regions Arcticæ Norvagiæ, p. 98, Christiana, 1878.

region where this form has been noticed is at Oexfjord in West Finmark, where my father found it boring in piles."

This Finmark colony of *Teredo norvegica* is far to the north of the northern margin of the continuous distribution zone of the species on the Norwegian coast.

B. Saumundson[1] writes as follows regarding the occurrence of Teredo in Icelandic waters: "The Icelandic name of Teredo, 'tremadkur,' was first mentioned as Icelandic by E. Olafssen in his journey through Iceland Soroe in 1772: '*Teredo navalis intra lignum* is the bad worm, which spoils the driftwood' (West Iceland). Later it is mentioned by Mohr, 1786 (Icelandic Natural History) and by Morch (Fauna Mollusc. Island), 1868, both on the authority of Olafssen, so that neither of these two men have noticed it in Iceland themselves.

The species was found living in a pier at Reykjavik by me five years ago, and definitely determined by Ad. Jensen as *T. norweviga* Spengl.

The species is found in driftwood all around the island. It was found by me only in standing lumber (piers) at Reykyavik (West coast)."

A Teredo listed as *T. navalis?* and *T. denticulata* is included in Mollier's[2] and Morch's[3] lists of the mollusca of Greenland. Posselt[4] refers Moller's *T. navalis* to *T. denticulata* which he records from a single locality in S. Greenland, avigtut.

The distribution of *Teredo navalis* along the Atlantic coast of Canada and New England affords an excellent example of discontinuous distribution. The essential features of this distribution are indicated in the sketch map (fig. 2), showing the distribution of Teredo in these waters. The map includes south of the Bay of Fundy the recorded occurrences of two or three species besides *T. navalis* but it clearly shows that the coast line distribution of this species is broken by 400 miles or more of coast line along which it is either absent or very rare. This mollusc is present in great abundance around the southern shores of the gulf of St. Lawrence and the coast of Cape Breton island. But southwest of the Str. of Canso it becomes scarce. In the Bay of Fundy, *T. navalis* is either very rare or entirely absent. South of this bay, however, it again becomes common on the Maine coast and from Frenchman's bay southwest appears to be generally present along the New England coast.

Mr. H. E. Miller has furnished the following notes on the distribution of *T. navalis* on the coast of Prince Edward Island: "Teredo is present in all waters surrounding the Prince Edward Island and up the inland tidal waters as far as the salinity of the water is sufficient.

"Regarding the coast of New Brunswick to the westward of this province, I cannot speak from personal observation never having visited that coast but from what I can learn the borer is to be found along the whole coast of Miscou and Shippigan and for at least a short distance along the Chaleur Bay coasts. I understand they do not work as far up to the rivers, as in this province. This is readily understood from the fact that the rivers are practically fresh very nearly to the outlet, draining immense areas and salinated by a very small range of tide.

"At Rustico Harbour on the North side of the island, there is great activity. The locality is entirely sandy. At Tignish, on the other hand, another sandy locality, the destruction is much less, but there is a very strong current, much sand in suspension, and considerable fresh water. The same comparison is true between localities of a muddy nature. Considering two localities, one sandy and one muddy, each with a considerable constant suspension of the material forming the bottoms, the destruction appears to be greater in the sandy locality."[1] The photograph here shown in fig. 1 indicates the great activity and abundance of *T. navalis* at Charlottetown on the south coast of the island.

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[1] Letter to the writer.
[2] Index Molluscorum Groenlandica, 1842, p. 21.
[3] Middelelser au Gronland, Vol. XXIX, 1905, pp. 289-362.
[4] Meddel. on Gronland, Band 23, 1898, p. 101.

Dr. Martin Murphy who made a special investigation of the distribution of Teredo in Nova Scotia stated that at Sydney Harbour, Cape Breton island, Nova Scotia, *T. navalis* is "as destructive if not more so than at any of the points on our coast."[1] It is abundant along the coasts of Northumberland strait as far west at least as Shediac." How much farther northwest its range extends is not known but probably not much farther. Murphy states that the zone of Teredo's operations on the east coast of Nova Scotia begins about Musquodoboit harbour and extends from there to Whitehaven.[2] He found that it became scarce on the Atlantic coast between the strait of Canso and Halifax. From Halifax southwest along the Nova Scotia coast only traces of Teredo are found and they are neither numerous nor destructive according to Murphy. The writer has not observed Teredo on the Bay of Fundy coast of Nova Scotia and Murphy does not appear to have seen it there. Dr. A. G. Huntsman of the St. Andrews biological station informs the writer that "we obtained it once near one of the Western isles, that is very close to Frye's island, in some sunken timber, and at another time we obtained it from some floating blocks which had, quite evidently, drifted in from outside, probably from the Gulf Stream. It is very probable therefore, that Teredo is not indigenous to the Bay of Fundy, but comes in periodically in floating wood." Professor Ganong reported in 1885 that "a broad and strong tide-dam was completely undermined and destroyed by them (*T. navalis*) within the space of six years."[3] at Frye's island which is located in the lower and wider part of the bay. This author at a later date however modified this statement by saying that the destruction of Frye's island was the combined work of Teredo and the crustacean *Limnoria lignorum*. It is possible that it was altogether the work of *L. lignorum* as suggested by Verrill. Whiteaves[4] records *T. navalis* from St. John in a ship's hull. But that this record represents exotic specimens appears certain from Professor Ganong's statement that in St. John harbour the Teredo is not only absent but "ships which enter the harbour infested by them are free from them within two days."[5] The testimony of Professor Verrill regarding the occurrence of Teredo in the Bay of Fundy is important because of his intimate knowledge of the Bay of Fundy fauna. He writes that "so far as I remember I did not find *Teredo navalis* in Bay of Fundy during the seven summers I collected there. I think I did find *T. norvegica* a few times in buoys." . . . "At Eastport, Me., I found Laminaria very abundant in piles, fish-weir stakes, etc., but found no Teredo with it there."[6]

At least three factors are probably active in excluding *T. navalis* from the Bay of Fundy. Temperature is doubtless one of these. The area in which Teredo is most abundant is, speaking broadly, essentially the same as that of the isolated colonies of oysters in the waters about the southern shore of the gulf of St. Lawrence. Although the waters in winter are much colder than those of the Bay of Fundy, during the critical period of the spawning time they are warmer. Professor E. W. McBride[7] has pointed out how the existence of the oyster in this region depends upon the warming of the water in the shoal areas where alone they can exist during the spawning season. Whiteaves[8] still earlier called attention to the special temperature conditions which afforded on the south side of the gulf of St. Lawrence a congenial environment for a northern colony of the Acadian fauna.

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[1] Murphy, M. On the Ravages of the Teredo Navalis and Limnoria lignorum on Piles and Submerged Timber in Nova Scotia and the means being adopted in other countries to prevent their attack. Proc. and Trans. Nova Scotian Inst. Nat. Sci., Vol. V, Part IV, 1882, pp. 357-376.

[2] Murphy, M. Supplementary Notes on Destroyers of the Submerged Wood of Nova Scotia, Proc. and Trans. N.S. Inst. Sci., Vol. 8, p. 218.

[3] Ganong, W. F. The Economic Molusca of Acadia, N.B. Nat. Hist. Soc. Bull. No. VII, 1888, p. 111.

[4] Catalogue of Marine Invertebrates of Eastern Canada, 1901, p. 151.

[5] Ganong, W. F. Nat. Hist. Soc. N.Y. Bull 4, p. 89, 1885.

[6] Verrill, A. E. Letter to the author, February 21, 1917.

[7] The Canadian Oyster, Can. Rec. Sci., Vol. IX, 1905, pp. 154-5.

[8] Catalogue of Marine Invertebrata of Eastern Canada, p. 15, Can. Geol. Survey, 1901.

Another factor of importance in controlling the distribution of Teredo is salinity. There appears to be general agreement among shipping men and others familiar with the work of Teredo that any considerable amount of fresh water is fatal to it. On this point, Mr. H. E. Miller states that "where the flow of fresh water is sufficient to have any effect on salinity there is an entire absence of Teredo."[1]

The speedy destruction of *T. navalis* already alluded to which results when it is brought into St. Johns harbour on ships is doubtless due to its inability to withstand brackish water. While this factor would explain its absence from certain bays and estuaries of the Bay of Fundy, neither salinity nor temperature will afford a satisfactory explanation of the general scarcity or absence of Teredo in these waters. If temperature alone were sufficient to bar Teredo from the Bay of Fundy it is difficult to understand how *Illyanassa obsoleta*, one of its congeners in the Acadian colony of the gulf of St. Lawrence should be able to make its way into the shallow bays on the east side of the Bay of Fundy, where I have found it at most points where I have dredged. This species on the opposite side of the Bay of Fundy is rare or absent.[2] One of the peculiarities of *T. navalis* is its aversion to water containing sediments or other impurities in suspension. Various writers have noted this aversion. The waters of the Bay of Fundy are unique in their extreme turbidity; no other waters on the American coast approach them in this respect. This is due to the very high tides, and the correspondingly swift currents in the estuaries which keep the waters near the coast everywhere turbid with sediment. In the Bay of Fundy there is a tidal range of 40 to 60 feet. In Northumberland Strait where Teredo is abundant the tidal range is in the neighbourhood of 10 or 12 feet. The turbidity of the Bay of Fundy waters, particularly in the upper and narrower portion of the Bay, exceeds that of Northumberland strait in somewhat the same proportion as its tides exceed those of the strait. The high turbidity of the estuarine waters of the Bay of Fundy is believed to be chiefly responsible for the general absence or scarcity of Teredo. Barrows[3] has pointed out that a definite correlation exists between the rock boring habit and a location on the open coast. The need of protection from the waves at and near the tide line on open coasts doubtless developed rock boring as a protective measure. This normal open-coast environment which involved exposure to the surf included the normal salinity of the open sea and comparative freedom from silt. The heavily silt laden waters of the upper part of the Bay of Fundy afford the very antithesis of the open coast environment which is normal to rock boring molluscs and in this fact is to be found the explanation of the absence or scarcity of *T. navalis* as well as the rock borers *Zirfaea crispata* and *Petricola pholadiformis* in the Bay of Fundy.

ASSOCIATED SPECIES.

A small crustacean, *Limnoria lignorum*, is associated with Teredo in some parts of its range whose wood-destroying habits are similar to those of Teredo. These two species which are similar only in habits, differ sufficiently in their preference for certain environmental factors to lead them to reach their maximum numbers and development along different parts of the coast line. Their zones of habitat, however, overlap according to Murphy. This author states regarding the areas occupied by these two species that "wooden wharves or bridges along the Bay of Fundy and from there along the Atlantic coast as far as Whitehaven suffer from the Limnoria, while the location of the Teredo is farther east and north." . . . "There is no neutral ground between them. Their domains overlap for a few miles, each of the little borers becoming less abundant as we advance farther into the territory of the other."[4]

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[1] Letter to the writer.
[2] Huntsman, Dr. A. G. Letter to the writer, February 5, 1917.
[3] Barrows, A. L. The Geologic Significance of Fossil Rock-Boring Animals, Bull. Geol. Soc. Amer., Vol. 1917.
[4] Proc. and Trans. N.S. Inst. Sci., Vol. 8, 1895, p. 218.

It is interesting to note that one of the molluscs which is common in Sydney harbour, Cape Breton island, where Teredo has perhaps its maximum abundance, is the rock borer *Zirfaea crispata*. Although reported rarely in the gulf of St. Lawrence by Whiteaves I have found it rather abundant near low-tide mark at North Sydney. Along the Bay of Fundy coast of Nova Scotia, however, I have found no trace of it. Stimpson reports it to be very rare at Grand Manan. Verrill has recorded it at from 8 to 70 fathoms in the Bay of Fundy. But it does not appear to occur in the Bay of Fundy near tide mark, as it does at Sydney. Like Teredo, *Z. crispata* appears to be absent or rare along the Atlantic coast south of the Bay of Fundy. This species, like *T. navalis*, has a wide distribution. On the Pacific coast it is reported from Vancouver to San Diego, California, by Carpenter.[1] It is distributed along the European side of the Atlantic from France to northern Norway.[2] Although found in an elevated beach near Christian shoal, Greenland, Jensen states "that *Zirfaea (Pholas) crispata* no longer lives at Greenland may be regarded as a fact."[3]

Another boring shell which is associated with *T. navalis* around the shores of Prince Edward Island is *Petricola pholadiformis*. The Canadian Geological Survey Museum collections include a specimen of hard red shale with shells of this mollusc from Charlottetown, P.E.I. Concerning this shell, Dr. A. G. Huntsman[4] writes: "*Petricola pholadiformis* is abundant in the lower part of the gulf of St. Lawrence around Prince Edward Island, and occurs boring in the red sandstone there. It has been reported by Verkruzen from St. Marys bay, Nova Scotia, and I have myself dredged it there in 30 fathoms hard clay bottom. I have not found it in the Bay of Fundy proper." Dr. Huntsman's observations on this shell indicates pretty clearly the discontinuous distribution of *T. navalis* and *Z. crispata*, which eliminates them from the fauna of the upper part of the Bay of Fundy.

Teredo navalis belongs in the gulf of St. Lawrence to an isolated faunal group which is confined to Dawson's warm "Acadian bay." The subboreal or syrtensian fauna of the central and northern part of the gulf of St. Lawrence are excluded from this fauna. Concerning this fauna, Dawson[5] wrote: "It thus forms a peculiar and exceptional zoological province" . . . "It affords to the more delicate marine animals a more congenial habitat than they can find in the Bay of Fundy or even on the coast of Maine."

Among the characteristic species which comprise this Northumberland strait colony of the Acadian fauna are the following:—

Ostrea virginica.
Venus mercenaria.
Zirfaea crispata.
Astarte undata.
Crepidula fornicata.
Crepidula plana.
Ilyanassa obsoleta.

Some of these species, as *O. virginica* and *V. mercenaria* are entirely absent from the Bay of Fundy waters. Some others, like *I. obsoleta* are entirely absent on the west coast of the Bay of Fundy but present in the warm shallow inlets on the eastern side of the bay. The Northumberland Strait colony is separated from the northeastern border of the New England zone of the Acadian fauna by the deep basin of the Bay of Fundy and the Atlantic coast waters of northern Nova Scotia. The

1 Dall considers the Pacific Coast form to be a species distinct from *Z. crispata*.
2 Adolf S. Jensen, Middelelser on Groenland, Vol. XXIX, 1905, p. 296.
3 *Ibid.*
4 Letter to the author, February 12, 1917.
5 Dawson, J. Annual address. Can. Nat. Ser. 2, Vol. VII, 1875, p. 277-8.

reason for this isolation becomes apparent on examination of a bathymetric chart of the waters of the Maritime Provinces. The whole of Prince Edward island and Northumberland strait lie inside the 20-fathom line, and much of the broad strait has a depth of 10 fathoms or less. On the southeastern coast of Nova Scotia, however, the 20-fathom line frequently approaches to within one-half mile of the coast, and there is everywhere a narrow zone of shoal water inside the 100-fathom zone which renders it colder than the broad shallow warm waters of Northumberland strait. It illustrates well the fact that a zone of shallow water if sufficiently close to and unprotected from deep waters may serve as a faunal barrier as effectively as a land barrier. This example of an isolated colony of the northern New England shallow zone marine fauna surrounded by a sub-boreal fauna is worthy of the attention of palæontologists who are prone to predict land barriers as offering the only possible explanation of faunal differences similar to those described above.

FORMER DISTRIBUTION OF THE NORTHUMBERLAND FAUNA.

There are several bits of evidence which seem to indicate that the present isolation and limited distribution of the colony of comparatively warm-water mollusca now living in the Northumberland strait with which *T. navalis* is associated is of recent origin. *Ostrea virginica*, the most strikingly southern type of this assemblage, apears to have extended as far westward as Montreal at one time during the Pleistocene. Several years ago Sir William Dawson wrote: "I have picked up a loose specimen at Saco which has the appearance of being a fossil specimen from the Leda clay, and Mr. Paisley has sent me specimens from Chaleur bay which are said to have come from Pleistocene beds 16 feet from the surface."[1] More recently Edward Ardley[2] has reported finding *Ostrea* near Montreal, 9 feet below the surface, associated with *Mya truncata, Macoma calcarea, Astarte, Laurentiana*, and *Saxicava rugosa*. At Cole Harbour on the east coast of Nova Scotia the flukes of anchors bring up numerous dead oyster shells, where the living oyster is unknown.[3]

On the east coast of Nova Scotia, Mr. W. J. Wintemburg of the section of Archaeology of the Geological Survey, has found in an old Indian shell heap on Mahone bay, 40 miles southwest of Halifax, shells of *Ostrea virginica* and *Venus mercenaria*. Neither shell is known south-west of Halifax, on the east coast of Nova Scotia at present, but their discovery in the shell heap appears to indicate that they lived in the bay when the shell heap materials were accumulating.

It may be suggested tentatively that the beds containing *O. virginica* at Montreal are synchronous in time with the Don River interglacial beds at Toronto. It is probable that the milder climatic conditions which prevailed during the early part of the Don River interval[4] rendered the temperature of the Atlantic coastal waters of the Maritime Provinces sufficiently mild to give the oyster and its congeners continuous distribution from southern New England to the gulf of St. Lawrence.

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[1] Dawson, J. W. Ice Age in Canada, 1893, p. 243.

[2] Ardley, Edward. "The Occurrence of Ostrea in the Pleistocene Deposits of the Vicinity of Montreal." Ottawa Naturalist, Vol. 26, 1912, p. 67.

[3] Proc. and Trans. N.S., Inst. Nat. Sci. Vol. I, 1863, p. 98.

[4] A. P. Coleman, Int. Cong. Geol., Guide Book, No. 6, 1913, pp.15-31.

Fig. 2.—Sketch map showing the discontinuous distribution of Teredo around the coasts of Nova Scotia and New Brunswick. The habitat of Teredo is shown by black border on coast line. Area where Teredo is absent or rare is shown without black border.

V

REARING SOCKEYE SALMON IN FRESH WATER.

By C. McLean Fraser, Ph.D., F.R.S.C., etc.

Curator of the Dominion Biological Station, Nanaimo, B.C.

In several instances, successful attempts have been made to rear the Atlantic salmon, *Salmo salar*, to maturity without permitting it to have access to the sea.

Yarrell[1] describes such an attempt that was made nearly a century ago as follows: "A large landed proprietor in Scotland . . . wrote as follows: 'In answer to your inquiry about salmon fry I have put into my newly formed ponds, the water was first let in about the latter end of 1830, and in April, 1831, I put in a dozen or two small salmon fry, 3 or 4 inches long, taken out of a river here, thinking it would be curious to see whether they would grow without the possibility of their getting to the sea or salt water. As the pond, between three and four acres in extent, had been newly stocked with trout, I did not allow any fishing till the summer of 1833, when we caught, with fly, several of those salmon, from two to three pounds' weight, perfectly well developed and filled up, of the best salmon colour outside, the flesh well-flavoured and well-coloured, though a little paler than that of new-run fish.' "

This attempt was successful as far as it went, but no evidence is given that any of the fish lived to maturity. It has been shown by Dahl, Hutton, and others that, in some rivers in particular, the Atlantic salmon commonly remains three years in fresh water, the length of time these were kept, without any artificial restraint. The experiment is interesting, however, since it shows that the retention idea is by no means of recent development.

Menzies[2] refers to this experiment and mentions others as follows:: " Since then various experiments in this direction have been conducted with more or less success, notably those by Sir J. Gibson Maitland, at Howietoun, where eggs deposited in the winter of 1880-1 were duly hatched and the fry reared until, when nearly four years old (i.e., the same age as grilse), they were found to be ready to spawn, and the ova of the females when fertilized by milt, were found to develop in a perfectly normal manner. In the report of the Fishery Board for Scotland for the year 1908, part II, appendix III, details are given of a male grilse kelt which, owing to an oversight, was left for a year in a small fresh-water 'catch-pit,' and which, in spite of these unnatural conditions, had again become ripe for spawning.

" Through the kindness of Mr. George Muirhead, the commissioner for the Duke of Richmond and Gordon, who sent the scales and particulars to Mr. Calderwood, I have been able to examine the scales of a somewhat remarkable fish, which died at the Tugnet hatchery, on the Spey, in August last. The details of the life of this most interesting specimen—a male—as supplied by the keeper of the hatchery are as follows: 'Hatched in April, 1905, the parr was placed in the rearing pond in the summer of the same year, and was retained there until the date of its death in August, 1911, when it weighed 4 pounds 3 ounces. During this period it spawned twice, for the first time in January, 1910, and for the second and last time in March, 1911; on the latter occasion its weight was 5 pounds 3 ounces, 1 pound more than when it died.'

[1] Yarrell, Wm. A history of British fishes, Part II, 1836, p. 21.

[2] Menzies, W. J. M. The infrequency of spawning in the salmon. Salmon Fisheries I, for 1911, Fishery Board for Scotland, 1912, p. 5.

"It is interesting to observe that, although this fish enjoyed steady hand feeding, it had only attained one-tenth of the weight it would, in all probability, have reached had it spent the last four years of its life in the natural manner in the sea, and the scales show that the feeding has been, as one might expect, of a regular character, and it would be impossible to estimate the age in the regular way. The absence of a spawning mark is at first sight particularly striking, although this is not so surprising when one remembers that a great deal of the erosion of scales takes place after the fish has ceased feeding and left the sea, and while it is in the river before spawning."

Masterman[3] makes reference to salmon that were bred in tanks at the Plymouth Marine laboratory. He says: "Through the courtesy of Dr. Allen, the Director of the Plymouth Marine laboratory, I was enabled to examine the scales of young salmon which were bred in the tanks, and for two successive seasons were 'stripped' of ripe ova and milt. Their scales show no trace of worn edge or of spawning mark." He gives a photograph of a scale of one of these salmon (see fig. 27).

Similar experiments have been carried on with the British "sea-trout", the migratory trout of the British coasts, the name applied to it by those who consider the "brown trout", said to be non-migratory, a different species and even by those who think the two are of the same species, developed under different conditions. Tate Regan[4] definitely states "In the British Isles there is only one species of trout." Lamond[5] gives an approving review of the arguments presented by Regan and in discussing one of these, viz., that sea trout, if prevented from going to the sea, will live and breed in fresh water, makes reference to an experiment carried out at Howietoun under the supervision of the hatchery superintendent, John Thompson, whose notes are recorded thus: "The parents were caught in a tributary of the river Forth, brought to Howietoun and spawned on November 23, 1886. There were 450 ova laid down to hatch of which some 350 hatched out successfully in February, 1887, and the fry (some 250) were shifted from the hatchery house to one of our ponds, in June of the same year and then fed the same as other fry. The young fish were again shifted into a larger pond in June, 1888, when the average size was found to be about three inches. In August, 1889, some specimen fish, about six inches in length, were taken from the pond by Dr. Day for examination and comparison with common trout, *S. fario*, and we were all agreed that it was impossible to distinguish them by the eye from *S. fario*. In April, 1890, the fish were again moved to another pond and I spawned some of the females in November of the same year, crossing the ova with milt from *S. levenensis* and *S. fontinalis*. A few fry of the former were hatched out and reared but were afterwards mixed with other fry. The remainder of the parent sea-trout were afterwards, I think, turned out into a reservoir, when about five years old. They never attained to any great size."

In all the cases mentioned, apparently the only difference observed between the fish retained in fresh water and those normally migrating is the difference in size, the retained specimens growing much more slowly than the normal migrating specimens. The scant supply of food in the fresh water as compared with the supply in the sea, which is commonly given as the reason for the slower growth in fresh water, apparently cannot be the controlling cause in all of these cases, since in some of them at least the fish may have been fed as much as they wished for. Possibly the lack of any necessity for special activity in search for food accounts for a similar lack of appetite and a sluggishness in digestion and a general condition that is not conductive to rapid growth. This would also account for any differences in external appearance and in

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[3] Masterman, A. T. Report on investigations upon the salmon with special reference to age determination by study of scales, Fishery Investigations, Board of Agriculture and Fisheries, series I, Vol. I, 1913, p. 31, London.

[4] Regan, C. Tate. The Fresh Water Fishes of the British Isles, 1911.

[5] Lamond, Henry. The Sea Trout, 1916.

the color of the flesh of the fish as well. The complete fresh water life, as far as these experiments show, causes no delay in the approach of the spawning period.

In only one of these cases was the later life of the fish followed up and reported upon. This fish survived two spawning periods and lived to be 6½ years old. There is thus nothing to indicate that its life was shortened in the continued existence in fresh water, nor can it be said definitely that it was prolonged.

Regan contends that there is no structural difference between the sea trout and the brown trout, but the difference in general appearance is due to the length of time spent in fresh water. That is to say, he is of the opinion that the brown trout is simply a sea trout that has given up migrating to the sea. Lamond apparently is of much the same opinion. If this contention is correct, and it is backed up by many convincing arguments, the continued life in fresh water must have a physiological effect if not a morphological, different to that when migration to the sea takes place, because the brown trout is so different in general appearance, when grown, that it is usually considered a different species or it might even be said many different species, where local conditions produce an appearance, different from the typical.

An experiment with the sockeye salmon, *Oncorhynchus nerka,* which is being carried on at the hatchery at New Westminster, B.C., by Hatchery Officer H. W. Doak, under the jurisdiction of Lieut.-Col. F. H. Cunningham, Chief Inspector of Fisheries for British Columbia, may be of greater interest than any of these. Already it is of sufficient importance to be worth recording.

In the fall of 1912 some sockeye eggs were taken from Harrison lake to the Bon Accord hatchery, where they hatched out in the spring of 1913. The fry were put into rearing ponds near the hatchery, but later, when the hatchery was moved over to Queen's Park, New Westminster, on account of Canadian Northern Railway operations, the fish were removed to ponds on the new site, where some of them still live and thrive.

In the fall of 1915 some of the males, then in their third year, became ripe and the milt was removed. The spent fish mended perfectly and continued to live and grow. As none of the spawning fish were marked, it was not possible to tell if those spawned again in 1916, but certainly some of the males spawned in that year. None of the females showed any signs of developing a spawning condition in the third year, i.e., in 1915, but they did so the following year. When they were ripe the eggs were removed, artificially mixed with milt for fertilization, and put in the hatchery, but although they remained fresh for a long period, none of them hatched out. The rest of the eggs were spawned naturally in the gravel at the bottom of the pond, but apparently they were not fertilized, as none of them hatched out either. The eggs were 5 to 5·5 mm. in diameter, somewhat smaller than even the smallest of normal sockeye eggs.

The spawning occurred about November 1, and on the 29th of January following a number of these fish were examined. There were nine of them altogether, running from 9 to 11 inches in length (not including caudal fin rays). They were not weighed, but probably none of them would weigh over a pound, and some of them not that much. The fish that had quit feeding during the spawning period, were taking food quite readily again and appeared to be perfectly mended. The skin was bright and metallic and the scales were shed quite readily.

Scales from four of them were taken for examination. Although there is much sameness in the rate of growth indicated throughout, it is possible in almost every perfect scale to make out the winter check somewhat readily. The growth is not quite regular even during the active part of the year, the irregularity is most noticeable in the second year's growth, but it is probably on account of the general slow growth that it is more noticeable in these than in normal scales. There may have been some disturbing influences in connection with their life in ponds as small as those in which they were kept.

A calculation made to get the amount of growth each year gave the following results in inches):—

	Total length.	1st year.	2nd year.	3rd year.	4th year.
	11·0	2·3	3·5	3·0	2·2
	9·7	3·0	3·5	1·9	1·3
	9·5	2·8	3·0	2·1	1·6
	9·5	2·7	3·3	2·3	1·2
Average..	9·9	2·7	3·3	2·3	1·6

The first of these was a female, and probably all of the others were males. There is a marked difference in the growth in the third year, but it cannot be stated with certainty that the small growth in the last three but particularly in the second one was due to the spawning of these males in the third year. There was no indication of a spawning mark on any of the scales. (This agrees with Menzies' statement for the Atlantic salmon, quoted above).

The great majority of the Fraser river sockeye remain in the fresh water for one year. The average growth of 614 four-year-old sockeye, hatched out at the same time as these and caught in the summer of 1916, is as follows:—

Total length.	1st year.	2nd year.	3rd year.	4th year.
22·3	2·9	8·6	7·7	3·1

No sockeye belonging to the same year class but remaining two years in the fresh water have yet been obtained as these are usually caught when in the 5th or 6th year, but a comparison may be made with the 5-year fish that were hatched out the preceding year. The average of 56 of these is as follows:—

Total length.	1st year.	2nd year.	3rd year.	4th year.	5th year.
22·5	2·6	3·2	8·2	6·1	2·4

I have not seen any sockeye from the Fraser that had remained in fresh water for three years, and as far as I am aware, none have been reported. Dr. Gilbert has reported some from the Nass river, that remained in fresh water for three years, but has given no figure of the scales. Even if the growth rate had been calculated for these Nass river fish, no direct comparison could be made with the Fraser river fish.

As far as comparison can be made, these pond-reared fish have a growth parallel to that of other sockeye, that remain in the fresh water under normal conditions, but the comparison can be carried only to the end of the second year. There is nothing to indicate that hand feeding in the pond makes any improvement in growth over natural feeding in the streams or lakes. The growth in length in the third year is less than that in the second, and that in the fourth less than that in the third, a decrease in somewhat the same portion, although not to the same extent, as is found in those living in the sea.

There is nothing remarkable in the fact that these fish lived over the fourth winter. Five year specimens are found in all types of sockeye, six years specimens are comparatively common and seven year specimens have been reported. The outstanding feature of the whole question lies in the fact that these fish have spawned and have mended perfectly and some of the males have lived over a year after the first spawning.

A large number of sockeye, as well as all other species of Pacific salmon, certainly die soon after spawning, and there is no convincing evidence that any of them long survive the spawning process under normal conditions, but these pond reared sockeye survived and began feeding again, apparently little the worse. They were examined again on April 20 and the nine of them were still alive, of good colour, and apparently in good health. It is true that they did not go through a wearing struggle in getting to spawning beds but that cannot have made all the difference because many of the Pacific salmon, even in some cases the sockeye, spawn in streams that are reached from the

sea with no special effort. The spawning effort itself should have been as severe on these as on those spawning under natural conditions or those artificially spawned. The physiological condition of the body must have become changed under the changed conditions of life, so that the fish has become, in its nature, more like a fish that normally remains in the fresh water throughout its existence. This may indicate that the genus *Oncorhynchus* is even more intimately related to the genus *Salmo* than has been suspected.

Mr. Doak has some pond-reared sockeye younger than these, and some coho at different stages as well, hence there is every chance for him to follow up the experiment far enough to get quite decided results.

EXPLANATION OF FIGURE.

The figure is from a photograph of a scale from a 4-year-old sockeye that was reared entirely in fresh water, taken from the fish on January 29. The numbers 1, 2 and 3, indicate the limit of the first, second and third year's growth, respectively. The margin is the limit of the fourth year's growth.

VI

ON THE AGE AND GROWTH OF THE POLLOCK IN THE BAY OF FUNDY.

By Professor JAMES W. MAYOR, Ph.D., Union College, Schenectady, N.Y.
(With one Diagram.)

I.—INTRODUCTION.

The present report represents the results of studies on the age and growth of pollock caught in the Bay of Fundy during the years 1915 and 1916. A report Mr. Douglas Macallum, prepared under the direction of the present writer, then curator of the St. Andrews Biological Station, dealing with the pollock caught in 1914, is already in the press. Mr. Macallum's report refers particularly to the older pollock of from three to six or more years growth, as determined by their scales. Besides working out the rate of growth of these pollock, he obtained indications that the most frequent year class was that of 1909. Some of the results of this report are included in the present paper for comparison with the data obtained in 1915 and 1916.

The object of the investigation has been to determine: (1) the distribution of the young pollock, (2) the rate of growth of young pollock during their first two or three years, (3) the relative frequency of the different year classes in typical commercial catches.

The writer is indebted to the members of the staff of the Biological Station at St. Andrews in 1915 and 1916 for assistance in measuring and taking the scales from fish. He is particularly indebted to Mr. E. Horne Craigie for the measurements made in July, 1915, and to Dr. A. G. Huntsman, the curator of the Station, for assistance and advice in obtaining the young pollock in 1916.

II.—METHODS OF MEASURING FISH AND STUDYING SCALES.

Two measurements for length have been employed. The *standard length* is measured from the tip of the snout to the end of the vertebral column (easily determined by feeling with the fingers). The *total length* is measured from the tip of the snout to the end of the tail, the caudal fin having its normal spread. In the case of fish over 20 cm. in length the measurements are always to the nearest centimeter; in the case of the smaller fish, under 20 cm., to the nearest millimeter. The standard length was chosen at the beginning of these investigations for the following reasons: (1) It can be more accurately determined by the ordinary methods, (2) it is not affected by the position or spread of the tail or by injuring the tail, (3) it measures the actual length of the body of the fish, (4) it has been found by Hjort, in the case of herring, that a better correspondence between actual lengths and lengths as calculated from the position of the rings on the scales is obtained by taking a length V measured from the anterior end of the pectoral fin to the end of the vertebral column, than by taking the total length. The standard length differs from V by the length of the head only, while the total length differs by the length of head and tail. The total length has been recorded for comparison with the measurements of the European investigators who use this length.

In 1914 the standard length only was recorded. In 1915, for catches No. 1 and No. 2, both the standard and total lengths were recorded, and for catches No. 3 to No. 5 only the standard lengths. In 1916 for catches No. 1 to No. 40, both standard and total lengths were recorded and for catches No. 41 to No. 62, the total length only.

The scales of the fish were taken in most cases from a region marked by the end of the right pectoral fin when extended along the side of the body in a posterior

direction. When the region had been injured either in capture or transport, the nearest uninjured region to this was used. The scales were stored in envelopes on which the length of the fish and other data were written. For microscopic study the scales were cleaned and flattened between two slides. In calculating the proportional lengths from the position of the winter rings, the positions of the outer edges of the winter rings were marked on strips of paper so placed that the edge of the paper coincided with the camera lucida image of the antero-posterior diameter of the scale in its anterior part. These strips were then placed on the apparatus devised by Hjort and the proportional lengths read off. For each fish, at least two scales were examined in this way.

III.—THE FIRST YEAR'S GROWTH.

A number of small Pollock, shown by their scales to be in their first year of growth were obtained. The greater number of these were caught in a shore seine about two fathoms in depth and twenty fathoms in length. The hauls were made in two localities and were as follows:

A.—North of Wilson's beach, Campobello island. Wilson's beach is on the western side of Campobello island and faces a stretch of tidal water lying between this island and the islands to the west of it, often called by the fishermen "The River". The Western shore of Campobello island descends somewhat abruptly, and, in consequence, the tidal current comes close to the shore. The hauls were made at about the time of low water on the morning of August 4, at which time many small pollock ranging around 35 cm. in length were seen in schools inshore. The results of these five hauls all made within a mile or two of each other, are grouped together and labelled catch No. 19. The separate hauls are given below.

Haul No. 1.—The seine was set a considerable distance from the shore so that the corks went under. The catch consisted of four pollock under 11 cm. and 1 pollock 42 cm. total length, and one flounder.

Haul No. 2.—The seine was set so that the cords just remained afloat. The catch consisted of seventeen pollock between 28 and 47 cm. total length, and no other fish.

Haul No. 3.—This was a short haul, the seine being set at about its own depth. The catch consisted of a few flounders and skulpins.

Haul No. 4.—This was a deep haul, the seine being set at about twice its own depth, the corks being completely under, on a beach covered with kelp. The catch consisted of fifteen pollock under 11 cm. total length, four skulpins, four flounders, and two sea ravens.

Haul No. 5.—This haul was made in shallow water and went foul of rocks. The catch consisted of a few flounders and a few skulpins.

B.—Bliss island. These hauls were made on the shores of a small island in the bay of Fundy, northeast of Campobello island and southwest of L'Etang harbour, where, as in the case af Wilson's beach, strong tides run. In all, six hauls were made and the catches numbered 28 to 33. Three hauls were made at low water on the evening of August 16, the seine being set in about its own depth. The hauls yielded the following small gadoids:—

Haul No. 1.—Two hake.

Haul No. 2.—Two pollock, forty-four cod, numerous hake.

Haul No. 3.—One pollock, two cod.

Three hauls were taken at the next low water on the morning of August 17, yielding the following small gadoids:—

Haul No. 1.—Numerous hake.

Haul No. 2.—Five pollock, four cod, and four hake.

Haul No. 3.—Four hake.

The length frequencies of the twenty-seven small pollock obtained in catches 19 and 29 to 32 are given in table I.

The length frequencies of the fish caught in the seine catches 19 and 29-32 form rather even curves with a mode at 8 cm. and 9 cm. The mean standard length of these fish, as calculated from measurements made to the nearest millimeter, is 8·7 cm., and the mean total length, as calculated in the same way is 9·7 cm.

The scales of these fish show a series of rings of plates corresponding to the centres of the scales of longer pollock. The number of these rings is from 4 to 10. In no case were the rings of plates close together, indicating winter growth.

In 1913 five small pollock were caught in the shore seine at Sandy Cove, N.S. Their length frequencies were as follows:—

Total lengths...	7 cm.	8 cm.	9 cm.	Standard lengths..	7 cm.	8 cm.
Frequency........	1	1	3	Frequency	2	3

The measurements were made to the nearest millimeter, and the mean total length was 8·2 cm. and the mean standard length 7·4 cm.

Seven other small pollock were obtained, five from weirs which had been seined for herring and two caught on hook and line from the station wharf. The length frequencies of these fish are given in table 2, and show that these fish were larger than those caught in the shore seine. Their mean standard length was 12·2 cm. and their mean total length was 13·3 cm. Their scales corresponding to their larger size show a greater number of rings of plates but do not show any winter rings. So far as any importance can be attached to the occurrence of these seven fish, it would seem to indicate that the young, after they attain a certain length, about 11 cm., move into slightly deeper water where they are not caught by the shore seine.

IV—THE SECOND YEAR'S GROWTH.

Among the pollock caught in the shore seine at Wilson's beach on August 4, as described in the previous section and grouped together as catch No. 19, eighteen were between 29 and 45 cm. total length. Two of these, specimens No. 660 and No. 661, 29 and 32 cm. total length, show only a single winter ring in their scales. The lengths of these fish at the end of their first winter as calculated from the positions of the winter rings in the scales is shown in table 3.

It is to be noted that these fish are probably large for their age being caught in a shoal with large fish. They constitute, however, the only data the writer has been able to obtain on pollock in their second year's growth. It is hoped in future work to fill this unfortunate gap in the investigations.

V.—THE THIRD YEAR'S GROWTH.

In all seventy-three pollock in their third year were caught. They were all caught in the shore seine near Wilson's beach, Campobello island, and are included in catches 17 and 19.

Catch 17 was taken on the morning of August 3, 1916, when numerous schools of small pollock were seen close inshore just north of Wilson's beach, and the shore seine was set at low water. One haul yielded fifty-seven specimens ranging between 30 cm. and 47 cm. in total length. The seine was rapidly hauled in over a rocky bottom and the only other fish caught was one *Pseudopleuronectes americanus* 35 cm. in length. The scales of these pollock all show two winter rings. The length frequencies are given in table 4. The mean total length is 39·6 cm. and the mean standard length is 36·4 cm.

Catch No. 19 has already been described in a previous section. It included sixteen pollock whose scales showed two winter rings. The total lengths of these fish at the ends of their first and second winters, as calculated from their scales, are given in table No. 5. The lengths given are, in each case, the average of two measurements on different scales. The mean total lengths of two-year old fish of the catch are, at the end of the first winter, 15·4 cm. and at the end of the second winter, 31·8 cm. The mean length of the fish when caught on August 4 was 39·2 cm. The mean increase in total length during the second year, t_2, was 16·4 cm. and the mean increase during the third year up to August 4 was 7·4 cm. The length frequencies of the fish in the different years of their growth are shown in table 6. The corresponding figures for the standard lengths are: mean standard length at end of first winter, 14·1 cm.; mean standard length at end of second winter, 31·3 cm; mean standard length when caught on August 4, 35·9 cm.

VI.—THE FREQUENCY OF THE DIFFERENT YEAR CLASSES IN THE YEARS 1914, 1915 AND 1916.

From measurements made on 1,250 pollock caught in July, 1914, Mr. Douglas Macallum constructed a length frequency curve, given in the paper already referred to. This curve, as Mr. Macallum noted, shows two modes, one at 63 cm., and one at 68 cm., the former being the more prominent one. The mean length of 6-year old fish (67·8 cm.) corresponds closely with the frequency curve at 68 cm., as scale studies show, and the mean length of 5-year old fish (63· cm.) with the mode at 62 to 63 cm. The most prominent mode is at 63 cm., i.e., 5-year old fish, or the class of 1909.

The material for the study of the pollock in 1915 consisted of the measurements and scales of 652 fish obtained in five catches from Casco bay, off Campobello island, New Brunswick. The first two of these catches were made on June 22, and included 331 fish, the other three catches were made on July 16, and included 321 fish. The length frequencies of these pollock, both the actual numbers caught and the per cent in each centimeter class, are given in table 7. In catches 1 and 2, both the standard and the total lengths were measured while the catches 3 to 5, only the standard lengths were taken. The table gives the standard lengths for all five catches and, in addition, the total lengths for catches 1 and 2. From the column in the table giving the per cent of specimens in each centimeter class for the first two catches and the similar column for the last three catches, it will be seen that they agree in showing the most frequent classes at 65 and 66 cm. Since the distribution of lengths in the catches is similar and since the catches were chosen at random, it would seem fair to assume that they represent correctly the distribution in point of size of fish caught during June and July in the vicinity of Campobello island. The frequency curve for the standard lengths of catches 1 to 5 is shown in the graph where the lengths have been grouped in 2 cm. classes and the frequencies plotted in per cent. This curve has a single mode at 66 cm., corresponding to the most frequent class in the per cent column. An examination of the scales of the fish from a typical catch, catch 2, was made in the

following manner: The envelopes, each containing the scales of a single fish, were arranged in the order of the standard lengths of the fish; the scales from every fourth envelope were examined and the number of rings counted. In this way, without examining scales from all the fish, scales from a representative sample of the catch were examined. The numbers of fish in each year class are shown in table 8. The mean standard length of the 5-year old fish of the class of 1910 was 63·9 cm., and that of the 6-year-old fish of the class of 1909 was 67·4 cm. The mode on the 1915 frequency curve is therefore seen to be due to the greater frequency of the 6-year-old fish of the class of 1909, or the same which gave rise to the most prominent mode in the 1914 frequency curve. The mean standard length of catches 1 and 2 is 67·5 cm., and the mean total length is 72·8 cm.

The material for the study of the pollock of three winters and over, in 1916, consisted of measurements of thirty-two catches made near Campobello island between July 10 and October 16. The first eleven of these catches, Nos. 2 to 18, were measured by the writer, both the standard and the total length being recorded and scale samples taken from each fish. The remaining catches were measured by Capt. Sheppard Mitchell of the Biological Station staff, and the total lengths recorded. The dates and locations of the catches and the number of pollock they contained are given in table 9.

The length frequencies of these catches have been tabulated and catches grouped according to the date of capture. Catches 2 to 12 were made betwen July 10 and 14; their standard length frequencies are given in table 10, columns I to X. From column IX it can be seen that the mode for these catches is about 66 c.m. The mode for catches 15 to 18 is seen from column XIV to be also 66 cm., although the frequencies of the 67 and 68 cm. classes are also large. Catches 2 to 18, which contain 567 fish, have been combined in columns XVI and XVII, which give the length frequencies in per cent. These columns show that the mode, in this case, is to be placed at 67 cm. The mode at 67 cm. is slightly in advance of the mode of the 1915 curve which is at 66 cm.

In the case of the remaining catches, numbers 41 to 62, the total length only was recorded. The catches are grouped according to the time of capture, July, August, first half of September, latter half of September, and October. In each of these groups the combined length frequencies of the separate catches, the per cent length frequency obtained by reducing the combined frequencies to per cent of the total number of fish concerned and the per cent frequency in classes of 2 centimeter intervals are given. The later percentages are each obtained by adding two of the percentages of the previous column. They are entered opposite the length of even number although they really correspond to a length which is the mean of the length of the two classes, the percentages of which were added, e.g. in column IV the per cent 8·0 corresponds to a length of 63·5 cm. The percentages in 2 centimeter classes are given because they make possible a more rapid inspection of the table. From table 11 it will be seen that the mode for catches 2 to 18 is 74cm., which may be taken to be the total length corresponding to 67 cm. The mode for catches 41 to 62 is at 80 cm. and it will be noted that this is approximately the mode of the separate groups of catches. The total length 80 cm., may be considered to correspond approximately to a standard length of 67/74 × 80 cm. or 72·5 cm.

During the summer of 1916, pollock were scarce around Campobello island, but they became more plentiful in the autumn. The catches 41 to 62 measured by Captain Mitchell are therefore regarded as more typical. It is these measurements which I have used in constructing the curve for 1916 in the graph. As these were measurements of the total length and the measurements for 1914 and 1915 were of the standard length the curve has been moved in the diagram so that its actual mode at 80 cm. comes at 72 cm. This has been done merely for the purposes of comparison. The form of the curve for total lengths is of course different from that for standard lengths. It is also to be considered that this curve represents fish caught later in the year than those used

for the 1914 and 1915 curves, a fact which would make the corresponding modal length less than that shown.

The numbers of winter rings have been counted for the scales of the fish of catches 3, 6 and 7, and the results are shown in table 12. The table shows that these catches, which had a mode at 67 cm., were composed predominately of 6-year-old fish. This being the case, the mode at 72 cm. of the curve for catches 41 to 62 shown in fig. 1, probably corresponds to the 7-year-old fish or the fish of the 1909 year class, the same which gave rise to the modes in the 1914 and 1915 curves.

VII.—SUMMARY.

1. It has been found that young pollock showing in their scales no winter rings and therefore probably in their first year's growth occur in shallow tidal water on the western coast of the Bay of Funday.

2. Data as to the rate of growth during the first two years are given.

3. Evidence is given for believing that the 1909 class has been the most abundant during the three years 1914, 1915, and 1916.

VIII.—TABLES.

TABLE 1.—Length Frequencies of Small Pollock caught in shore seine in 1916.

A. Standard Lengths—Numbers in columns represent number of specimens in centimeter groups.

Length	7 cm.	8 cm.	9 cm.	10 cm.	11 cm.
Catch 19	3	6	8	2	
Catch 29-32	-	3	-	4	1
Total	3	9	8	6	1

B. Total Lengths—Numbers in columns represent number of specimens in centimeter groups.

Length	7 cm.	8 cm.	9 cm.	10 cm.	11 cm.	12 cm.
Catch 19	2	4	7	5	1	-
Catch 29-32	-	1	2		4	1
Total	2	5	9	5	5	1

TABLE 2.—Length Frequencies of Small Pollock, Catches Nos. 21-26, five seined in herring weirs and two caught with hook and line from Station wharf August 3 to 9.

A STANDARD LENGTHS.

Lengths	11 cm.	12 cm.	13 cm.	14 cm.	15 cm.
Frequency	3	1	1	2	-

B—TOTAL LENGTHS.

Lengths	11 cm.	12 cm.	13 cm.	14 cm.	15 cm.
Frequency	1	2	1	1	2

TABLE 3.—Calculated Lengths of Pollock from Catch No 19, showing a Single Winter Ring.

—	Standard Lengths.		Total Lengths.	
	1st. Ring.	Length.	1st. Ring.	Length
Specimen 660	19 cm.	27 cm.	20 cm.	29 cm.
" 661	20	29	22	32

TABLE 4.—Length Frequencies of Pollock of Catch 17.

A. Standard Length Frequencies in Centimeter Classes.

Cm. Class	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Frequency	1		1	-		1	1	8	10	16	3	3	2	3	3	3	1	1

B. Total Length Frequencies in Centimeter Classes.

Cm. Class	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Frequency	1	-	1	-	-	1	1	7	11	14	5	2	2	2	4	3	2	1

TABLE 5.—Lengths of Pollock of Catch 19 at the end of each of their first two winters as calculated from their scales and their lengths when caught.

Specimen No.	Standard Length.			Total Length.		
	1st. Ring. 1915.	2nd. Ring. 1916.	Edge. 1916.	1st. Ring. 1915.	2nd. Ring. 1916.	Edge. 1916.
662	12	27	32	13	30	35
663	12	29	34	13	32	37
664	14	28	33	15	32	37
665	13	31	35	14	34	38
666	14	29	35	15	32	38
667	14	28	36	15	30	39
668	13	32	36	14	35	39
669	14	31	36	16	34	39
670	15	32	36	16	35	39
671	17	31	36	19	33	39
672	14	32	36	15	36	40
673	14	33	37	15	36	40
674	17	34	37	19	37	40
675	13	33	38	14	36	41
676	13	33	37	14	36	41
677	17	37	41	19	40	45
Mean	14·1	31·3	35·9	15·4	31·8	39 2

TABLE 6.—Length Frequencies of Pollock of Catch No. 19, those at the end of first and second winters being calculated from their scales.

Length cm	13	14	15	16	17	18	19
Frequency	2	4	5	2		–	2

Length cm	30	31	32	33	34	35	36	37	38	39	40
Frequency	1		3	1	2	2	4	1			1

Length cm	35	36	37	38	39	40	41	42	43	44	45
Frequency	1		2	2	5	3	2	–		–	1

TABLE 7.—Length Frequencies of Pollock caught in 1915 and Comprising Catches Nos. 1 to 5.

Length in cm.	Standard Lengths.								Total Lengths.		
	No. in Catch.		% in each cm. class.	No. in Catch			% in each cm. class.		No. in Catch.		% in each cm. class.
	1	2	1–2	3	4	5	3–5	1–5	1	2	1–2
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
52	1		·3					·2			
55				2			·6	3			
56					2	1	1·0	·5			
57				1		2	1·0	5	1		3
58	4	1	1·5	1	1		6	1·4			
59	2	3	1·5	2			·6	1·4			
60	2	4	1·8	3	3		1·9	1·8			
61	7	5	3·6	5		1	1·9	2·8			
62	19	10	8·8	6	9	6	6·7	7·7			
63	20	13	10·0	5	5	1	3·5	6·7			
64	24	12	10·9	8	12	2	7·1	8·9	4	1	1·5
65	27	11	11·5	10	15	13	12·2	11·7	2	3	1·5
66	19	20	11·8	9	15	7	9·9	10·7	1		·3
67	15	9	7·3	5	16	9	9·6	8·3	8	5	3·9
68	13	12	7·6	9	19	8	11·6	9·4	9	11	6·1
69	3	7	3·0	7	11	7	8·0	5·4	19	12	9·4
70	8	8	4·8	6	7	6	6·1	5·4	22	9	9·4
71	7	5	3·6	1	5	5	3·5	3·5	15	10	7·6
72	9	2	3·3	2	3	8	4·2	3·7	25	14	11·8
73	4	4	2·4	4	2	1	2·2	2·3	19	18	11·2
74	4	1	1·5	3	2	2	2·2	1·8	13	7	6·1
75	2	5	2·1	2	2	6	3·2	2·6	10	8	5·4
76	2	2	1·2	1		1	·6	·9	7	7	4·2
77	1	1	6	1		4	1·6	1·4	5	5	3·0
78	2		·6		1	1	·6	·6	5	7	3·6
79	1		·3	1		2	·9	·6	7	4	3·3
80						2	·6	3	8	4	3·6
81					1		·3	·2	4	1	1·5
82						1	·3	·2	4	1	1·5
83									1	4	1·5
84									2	1	·9
85									2	3	1·5
86											
87									3		·9
Total.	196	135		94	131	96					

NOTE.—Lengths are to nearest centimeter.
Numbers refer to catch numbers.
Date of Catches Nos. 1-2, June 22.
Date of Catches Nos. 3-5, July 16.

TABLE 8.—The Age Frequencies of Pollock caught in 1915, Catches 1 to 5.

Number of winter rings	4	5	6	7	8
Year class	1911	1910	1909	1908	1907
Frequency	1	13	17	2	1

TABLE 9.—Catches of Pollock examined in 1916.

Catch.	Date.		Place.	No. of Pollock.
2	July	10	Off East Quoddy Light, Campobello Island	10
3	"	11	do.	66
6	"	12	do.	45
7	"	13	do.	74
10	"	14	do.	29
11	"	14	do.	45
12	"	14	do.	31
15	Aug.	2	Wolves	68
16	"	2	"	168
18	"	3	Off Casco Bay Island, Campobello Island	31
41	Sept.	4	Off Pope's Folly, near Campobello Island	40
42	"	4	do.	40
43	"	4	do.	33
44	"	5	do.	55
45	"	6	do.	24
46	"	7	do.	21
47	"	7	do.	15
48	"	7	do.	22
49	"	11	do.	11
50	"	11	Off Green Island Shoal, near Campobello Island	10
51	"	20	do.	19
52	"	28	do.	35
53	"	28	do.	21
54	"	28	do.	41
55	Oct.	2	do.	96
56	"	3	do.	139
57	"	4	do.	87
58	"	5	do.	98
59	"	6	do.	89
60	"	7	Off Pope's Folly, near Campobello Island	94
61	"	12	Off Indian Island, near Campobello Island	100
62	"	16	Off Green Island Shoal, near Campobello Island	78

TABLE 10.—Standard Length Frequencies of Catches 2 to 18.

Length in cm.	Frequency in each catch.							Catches 2–12, July 10–14. Per cent in each cm. class.		Frequency in each catch			Catches 15–18, August 2–3. Per cent in each cm. class.		Catches 1–18, July 10–Aug. 3. Per cent in each cm. class.	
	Catch 2, July 10.	Catch 3, July 11.	Catch 6, July 12.	Catch 7, July 13.	Catch 10, July 14.	Catch 11, July 14.	Catch 12, July 14.	1 cm.	2 cm.	Catch 15, Aug. 2	Catch 16, Aug. 2	Catch 18, Aug. 3	1 cm.	2 cm.	1 cm.	2 cm.
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
40..	....	......	..	..	.		1	.3	.3						.2	.2
47..	..	....	.....	...	.	....	1	.3	.3						.2	.2
50..			.....	.			.			2			.4	.4	.2	.2
51..	...		1	...	...	.		.3	.3		1		.4		.4	
52..	...	...	.....	1				.3	.6					.4	.2	.6
53..	....	....	....	3	..	..		1.6		1	1		.7		.9	
54..	......	..		1	.	3	.	1.3	2.3	5	2		2.6	3.5	1.9	2.8
55..	.....	2	..	1	1	1	2	2.3		3	1		2.6		2.5	
56..	.....	1	...	1		3	2	2.3	4.6	4			1.5	1.1	1.9	1.1
57..	......	3	1	3	1	3	2	5.3		1	6		2.6	.	4.1	
58..	......	.....	4	3	..	3	2	4.0	9.3		2	1	1.1	5.7	2.7	6.8
59..	...	4	3	2	.	4	3	5.3			1		.4		3.0	
60..		3	2	2	..	4	3	4.7	10.0		2		7.7	8.1	2.8	5.8
61..	1	4	1	3	3	4	2	6.0		2	5		2.6		4.4	
62..	2	5	2	6	2	4	1	7.3	13.3		1	3	1.5	1.1	4.6	9.0
63..	2	2	2	4	1	5	2	6.0			8	1	3.4		4.8	
64..	1	..	4	3	3	3	1	5.0	11.0	2	13	1	6.0	9.4	5.5	10.3
65..		4	7	6	3		3	7.7		5	9	1	5.6		6.7	
66..	......	6	3	6	4	4	1	8.0	15.7	8	18	2	10.3	15.9	9.2	15.9
67..	1	3	2	5	1	2	.	4.7		7	16	2	9.4		6.9	
68..	1	8	3	9	1	1	1	8.0	12.7	6	12	5	8.6	18.0	8.3	15.2
69..	....	4	2	4	..	1	1	4.0	.	4	11	4	7.1		5.5	
70..	1	5	3	2	1	.	2	4.7	8.7		13	1	5.3	12.4	5.0	10.5
71..	1	2	1	1	.	...	.	1.7		6	5	3	5.3		3.4	
72..	......	5	....	3	1	...	1	3.3	5.0		5	1	2.3	7.6	2.8	6.2
73..	...	3	...	1	1		.	1.7	..	3	5	4	4.5		3.0	
74..	......	1	1	1	1			1.3	3.0	1	5		2.3	6.8	1.8	4.8
75..	.....	....	....	2	2	...		1.3		..	7	.	2.6		1.9	
76..	....	1	......	....	...	....	...	.3	1.6	4	3		2.6	5.2	1.4	3.3
77..	....	......	1	....	....	..		.3	..	3	3		2.3		1.2	
78..	....	...	......	....	...	..	..			1	1	1	1.1	3.1	.5	1.7
79..	......	....	...	...	.	....	.				5		1.9		.9	
80..	....	....	1	......	....	....	..	.3	.3	.	1	.	1.5	3.4	.9	1.8

81			1					3							2	
82				1				3	3			1	·4	4	·4	·6
83										1			·4		·2	
84														4		2
Total	10	66	45	74	29	45	31			68	168	31				

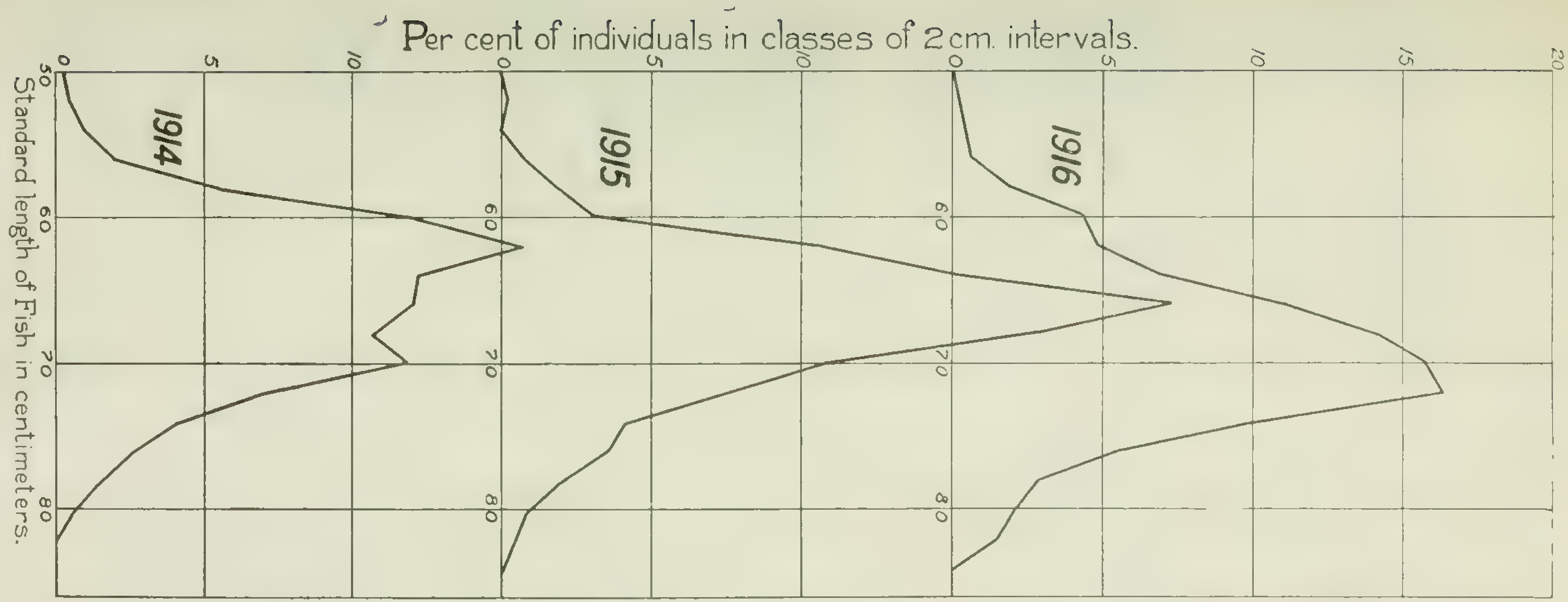
TABLE 11.—Total length frequencies of catches 2 to 62.

	Catches 2-12, July 10-14.			Catches 15-18, August 2-3.			Catches 41-50, September 4-11.			Catches 51-54, September 20-28.			Catches 55-62, October 2-16.			Catches 2-18.		Catches 41-62.	
	Combined frequency.	in each cm. class.	% in each 2 cm. class	Combined frequency.	% in each cm. class.	% in each 2 cm. class	Combined frequency	in each cm. class.	% in each 2 cm. class	Combined frequency.	% in each cm. class.	% in each 2 cm. class	Combined frequency.	in each cm. class.	in each 2 cm. class	in each cm. class.	in each 2 cm. class	% in each cm class.	in each 2 cm. class
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX
44	1	3	·3													·2	·2		
52	1	·3	·3													·2	2		
55	0	0		1	4								1	·1		2		1	
56	0	·0	·0	0	·0	4							0	·0	1	0	2	·0	·1
57	1	·3		1	·4								0	0	0	·4		·0	
58	3	1·0	1·3	2	7	1·1							0	0	0	9	1·3	·0	·0
59	3	1·0		5	1·9								2	·3		1·4		·2	
60	6	2·0	3·0	5	1·9	3·8							0	·0	·3	1·9	3·3	·0	2
61	6	2·0		7	2·6								3	4		2·3		3	
62	8	2·7	4·7	2	7	3·3							1	·1	·5	1·8	4·1	·1	·4
63	12	4·0		7	2·6								3	4		3·4		3	
64	12	4·0	8·0	3	1·1	3·7							3	·4	8	2·6	5·0	·3	·6
65	11	3·7		0	·0								11	1·4		1·9		·9	
66	13	4·7	8·4	2	·7	·7	1	·4	·4				11	1·4	2·8	2·6	4·5	1·0	1·9
67	15	5·0		3	1·1		2	·7		1	·9		20	2·6		3·2		2·0	
68	17	5·7	10·7	8	3·0	4·1	3	1·1	1·8	5	4·3	5·2	20	2·6	5·2	4·4	7·6	2·4	4·4
69	18	6·0		7	2·6		4	1·5		1	·9		16	2·1		4·4		1·8	
70	13	4·7	10·7	7	2·6	5·2	7	2·6	4·1	2	1·7	2·6	26	3·3	5·4	3·5	7·9	3·0	4·8
71	15	5·0		15	5·6		3	1·1		4	3·4		29	3·7		5·3		3·1	
72	17	5·7	10·7	21	7·9	13·5	10	3·7	4·8	3	2·6	6·0	31	4·0	7·7	6·7	12·0	3·8	6·9
73	22	7·3		18	6·7		11	4·1		6	5·2		41	5·3		7·1		5·0	
74	16	5·3	12·6	26	9·8	16·5	6	2·2	6·3	6	5·2	10·4	58	7·4	12·7	7·4	14·5	6·0	11·0
75	27	9·0		19	7·1		16	5·9		12	10·3		42	5·4		8·1		6·0	
76	11	3·7	12·7	18	6·7	13·8	26	9·6	15·5	12	10·3	20·6	57	7·3	12·7	5·1	13·2	8·1	14·1
77	10	3·3		14	5·2		11	4·1		6	5·2		67	8·6		4·2		7·2	
78	7	2·3	5·6	10	3·7	8·9	20	7·4	12·5	14	12·1	17·3	73	9·4	18·0	3·0	7·2	8·6	15·8
79	10	3·3		8	3·0		23	8·5		9	7·7		59	7·6		3·2		7·8	
80	8	2·7	6·0	14	5·2	8·2	28	10·2	18·7	9	7·7	15·4	63	8·1	15·7	3·9	7·1	8·6	16·4
81	3	1·0		6	2·2		15	5·5		5	4·3		52	6·7		1·6		6·2	
82	6	2·0	3·0	4	1·5	3·7	16	5·8	11·3	9	7·7	12·0	33	4·2	10·9	1·8	3·4	5·0	11·2
83	3	1·0		5	1·9		17	6·3		5	4·3		22	2·8		1·4		3·8	
84	1	3	1·3	7	2·6	4·5	7	2·6	8·9	0	·0	4·3	14	1·8	4·6	1·4	2·8	1·8	5·6

85	1	·3	....	5	1·9	....	9	3·3	....	1	·9	....	8	1·0	....	1·1	....	1·5	....
86	....	....	3	6	2·2	4·1	7	2·6	5·9	4	3·4	4·3	5	·6	1·6	1·1	2·2	1·4	2·9
87	....	....	....	1	·4	....	6	2·2	....	1	·9	....	3	·4	....	·2	....	·9	....
88	....	....	....	4	1·5	1·9	9	3·3	5·5	1	9	1·8	4	·5	9	·7	9	1·2	2·1
89	....	....	....	4	1·5	....	6	2·2	....	....	....	....	3	·4	....	1·1	....	·8	....
90	....	....	....	1	·4	1·9	8	3·0	5·2	....	....	....	....	....	·4	·4	1·5	·7	1·5
91	....	....	....	0	·0	....	....	....	....	....	....	....	....	....	....	·0	....	....	....
92	....	....	....	1	·4	·4	....	....	....	....	....	....	....	....	....	·2	·2	....	....
Total in caches	300	....	....	267	....	....	271	....	....	116	....	....	781	....	....	....	....	....	....

TABLE 12.—Length frequencies of the Pollock of catches 3, 6 and 7, arranged according to age and catch.

Length to nearest cm.	Catch 3.			Catch 6.			Catch 7.		
	No. of winter rings.			No. of winter rings.			No. of winter rings.		
	4	5	6	4	5	6	4	5	6
51				1					
52							1		
53							3		
54							1		
55	2						1		
56	1						1		
57	3				1		2	1	
58				4				3	
59		1		1	2			2	
60		2	1		2			2	
61	1	2	1		1		1	1	1
62		5			2			6	
63		2			1	1		2	1
64					1	3	1	1	
65		1	3		4	2		1	4
66		2	2		2	1		2	3
67		2	2			2		1	4
68		5	5		1	2		1	8
69		3	3		1	1		1	3
70		2	2		2	1		1	2
71		1	1			1			
72		3	3					1	2
73		2	2						1
74		1	1			1			1
75								1	1
76		1	1	1					
77									
78									
79									
80									
81									
82									1
Total...	7	38	27	7	20	15	11	27	32
Mean lengths..	56·9	62·9	68·6	59·9	63·8	66·3	55·9	63·3	68·4



Curves showing length frequencies of Pollock caught in 1914, 1915 and 1916.

The curves for 1914 and 1915 are constructed from measurements of the standard length and are based upon measurements on 1,250 fish in the case of the 1914 curve and in the case of the 1915 curve on 652 fish. The curve for 1916 is based on measurements of the total length of 1,168 fish. In order to compare it with the curves for 1914 and 1915 the whole curve has been moved to the left so that the mode which was at 80 cm. is at 72 cm.

VII

FURTHER HYDROGRAPHIC INVESTIGATIONS IN THE BAY OF FUNDY.

By E. Horne Craigie, B.A., University of Toronto and W. H. Chase, B.A., Acadia University.

(*With 25 figures and 1 map.*)

During the summer of 1914 a hydrographic section of the Bay of Fundy was made, a report of which appeared in the *Contributions to Canadian Biology*, 1914-1915.[1] At the beginning of July, 1915, it was suggested that a considerable amount of dredging should be done with a view to working out the fauna of the Bay of Fundy, and the opportunity was taken to combine with this work a repetition of the hydrographic observations made in the previous year and to extend them over the greater part of the Bay. It was thus possible to collect sufficient data to give a general idea of the conditions existing in the water of this important and interesting region.

OBSERVATIONS MADE AND APPARATUS EMPLOYED.

The work was carried out during two cruises in the month of July. The first of these enabled dredging to be carried on at twenty-four stations in St. Mary bay, Nova Scotia, and observations to be taken at stations I to IV in the Bay of Fundy—the stations which were established in 1914. The work of the second cruise comprised dredging at nine stations in the Annapolis basin and the establishment of two more cross-sections and a longitudinal section of the Bay of Fundy.

In St. Mary bay and the Annapolis basin, the stations in which were numbered consecutively in Arabic numerals, temperatures and water samples were taken at the surface and at the bottom at each dredging station, largely for the sake of the connection of these conditions with the fauna found. At all the Bay of Fundy stations, observations were made at the surface, at depths of 5 and 10 fathoms, and then at 10 fathom intervals to the bottom. In the table of data the records for the bottom have been put opposite the nearest depth in tens of fathoms. The exact depth of the observation may be seen at a glance from the record of "Depth" near the top of the column for each station. The hydrographic data obtained in St. Mary bay and the Annapolis basin are tabulated here chiefly in order that they may be accessible when required, though few deducations can be made from them at present. At the Bay of Fundy stations V to XV, dredge hauls were taken; and at these and the Annapolis basin stations, surface plankton samples were also obtained.

The apparatus employed was the same as that used in 1914, and has been described in the report of the work done in that year. The temperature of the air and of the surface water were taken by means of a delicate chemical thermometer, all other temperatures were determined by reversing thermometers. The temperatures at 5 and 10 fathoms at station III, and from 10 to 40 fathoms at station IV, were determined by a Negretti-Zambra thermometer,[2] all other temperatures below the surface by a Richter thermometer.[3] The water samples were obtained by means of a Petterssen-

[1] Craigie, E. Horne. "A Hydrographic Section of the Bay of Fundy in 1914."
[2] Magnaghi pattern frame, Negretti and Zambra thermometer No. 170664.
[3] Laboratoire Hydrographique, Kobenhavn, Preisliste, 1914, No. 75, thermometer No. 164.

Nansen water-bottle. A full description of both this water-bottle and the reversing thermometers may be found in the section on hydrographic work in the report on the "Investigation of the Bays of the Southern Coast of New Brunswick with a view to Their Use for Oyster Culture."[1]

The temperatures read on the Richter thermometer were all corrected for the expansion of the mercury column at the temperature at which the reading was made, and the corrected figures were recorded in the tables and used in constructing the temperature curves. All temperatures are in the centigrade scale.

The densities and salinities of the water samples were determined by W. H. Chase, but as he was called away by military duties, he was unfortunately prevented from completing the work.[2] Such discrepancies between density and salinity in many cases were found in the records that it was considered necessary to repeat the analysis of the samples, and Professor Vachon of Laval University was so kind as to do this during the summer of 1916. Unfortunately, Prof. Vachon found that the water samples must have altered by evaporation since they were collected, and it has accordingly been regretfully decided not to publish the data for the Bay of Fundy stations, but to confine this report to the temperature observations. The densities, salinities and chlorine contents of the samples from St. Mary bay, as determined by W. H. Chase, will be found in table III at the end of the report.

LOCATION OF OBSERVATION STATIONS.

The positions of all the stations are indicated on the accompanying map, on which the fifty and hundred fathom lines have also been inserted, giving an idea of the conformation of the bottom of the Bay. The stations were located so as to give as complete sections as possible, showing the conditions existing in the various parts of the water. In making the observations, the stations were found by the use of a log.

Stations I to IV are on a straight line drawn from East Quoddy Head, Campobello island, to Boar's Head, Petit Passage, Long island, as follows:—

Station	I	7	miles from East Quoddy Head.
"	II	19	" " " "
"	III	27	" " " "
"	IV	37	" " " "

The remaining Bay of Fundy stations are located as follows:—

Station	V	22	miles	N.W. from Digby Gut.
"	VI	8	"	S. from Partridge Island, St. John Harbour.
"	VII	14½	"	S. from Partridge Island, St. John Harbour.
"	VIII	21½	"	S. from Partridge Island, St. John Harbour.
"	IX	28	"	S. from Partridge Island, St. John Harbour.
"	X	11½	"	E. from Station VII.
"	XI	5	"	S. from Quaco Head.
"	XII	10½	"	" "
"	XIII	15½	"	" "
"	XIV	20½	"	" "
"	XV	16	"	S.E. by S. from Quaco Head.

The distances are measured in geographical miles.

[1] Mavor, Craigie, and Detweiler in "Contributions to Canadian Biology, 1914-15."

[2] The responsibility for the planning of the work, selecting the stations, etc., rests with E. Horne Craigie, as does also the recording and working up of the temperature data, while observations on density and salinity were in charge of W. H. Chase. The two workers collaborated on the draft of the earlier part of this report, and on the preparation of the accompanying map and some of the figures. Owing to Mr. Chase's departure for the front, it has been necessary to complete the report without his assistance or criticism.

DEDUCTIONS FROM DATA OBTAINED IN THE BAY OF FUNDY.

A.—Temperature Curves.

From the corrected data obtained at each station, a temperature curve has been drawn (figs. 1-15), and upon the basis of these curves four profiles have been constructed representing respectively the three transverse sections and one longitudinal section of the Bay of Fundy. The discrepancies in depth at some stations shown by the curves and profiles are to be explained by the state of the tide when the observations were made. The bottom conformation has been drawn as accurately as possible with the aid of charts.

If the data for stations I to IV be compared with those recorded in August, 1914,[1] it will be observed that, with the exception of the surface temperatures at stations II and IV, all the readings are considerably lower in the new observations, the bottom temperatures averaging 2.7° lower than in 1914. The range of temperatures between the surface and the bottom is thus much greater in 1915, the difference in the surface temperatures being comparatively little. These differences between the temperatures found in the two years are to be explained, no doubt, by the fact that the new observations were taken six weeks earlier in the season than the old ones, when the heating effect of the summer sun and air had had less time to penetrate to the deeper water. Thus there is to be seen a very rapid fall of temperature in the layers of water near the surface (figs. 1-4). In this connection, it must be remembered that the heat conductivity of sea water is so slight as to be practically negligible. "The heat conveyed by the sun to the uppermost water-layers cannot therefore be propagated into deep water by conduction, but only through movements of the water-waves, currents, convection 'currents,' etc."[2] The fact that the deeper water is heated so much in a period of six weeks must be attributed to the vertical mixing of the water by the great tides occurring in this region.

Another effect of this vertical mixing by the strong tidal currents was referred to in the previous report, namely, the considerable areas of the same, or nearly the same temperature occurring at many of the stations. This is most marked in the case of the stations farther up the Bay, the temperatures at stations X to XV (figs. 10-15) inclusive being practically constant between a depth of 5 fathoms and the bottom. The fact that this uniformity becomes more marked in the upper part of the Bay bears out the theory that the tides are responsible for it, the tides being greatest at the head of the Bay, while the water there is shallower, so that the tides are likely to effect a more complete mixing of the mass of water.

Helland-Hansen, generalizing upon the basis of temperature curves for four stations distributed over the Atlantic from the Faroe-Shetland channel to the Sargasso Sea says: "From the surface downwards the temperature falls very rapidly for the first hundred metres; at 100 metres it is 4° to 6° colder than at the surface. Beyond 100 metres the temperature decreases at first much more slowly. . . . The layers in which the temperature changes very rapidly are called 'discontinuity layers' (by the Americans 'thermocline,' and by the Germans 'Sprungschicht')."[3] The curves obtained for the first four Bay of Fundy stations, i.e. those nearest the open Atlantic, (figs. 1-4) agree with these observations to an extent which seems little short of remarkable in shallow and enclosed water, especially where conditions are so peculiar as they are in the Bay of Fundy. Indeed it would hardly seem justifiable to consider the correspondence as more than a matter of chance were it not for the fact that it appears even more clearly in the curves for the same stations in August, 1914. The comparison is made particularly apt

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[1] Craigie, E. Horne. "A Hydrographic Section of the Bay of Fundy in 1914." Contributions to Canadian Biology, 1914-1915.

[2] Helland-Hansen in "The Depths of the Ocean," by Sir John Murray and Dr. Johan Hjort, p. 226.

[3] "The Depths of the Ocean," p. 223.

by the fact that Helland-Hansen's observations were made between June 24 and August 10—at practically the same time of year as our own work.

While the density and salinity records are not being included in this report, for the reasons explained above, it is perhaps worth while remarking in this connection that the observed densities also correspond rather closely with the records obtained in the part of the open Atlantic near Nova Scotia by the *Challenger* expedition in May 1873. The surface densities for the *Challenger* stations 49 and 50 are, respectively, 1.02354 and 1.02451, the bottom readings for the same stations being 1.02400 and 1.02546. The depth at station 49 was only 85 fathoms, that at station 50 was 1,250 fathoms.[1]

The surface and bottom densities found at our stations I to IV were:—

Station—	I.	II.	III.	IV.
Surface	10242	10240	10239	10246
Bottom	10246	10250	10252	10252

The surface densities throughout the Bay varied from 10238 (stations VI and VII) to 10248 (station XIII). The bottom densities ran from 10244 (station X) to 10252 (stations III and IV). Thus it appears that the density of the waters of the Bay of Fundy corresponds quite closely with that of the neighbouring part of the Atlantic. Once more, no doubt, the thorough mixture brought about by the tides is to be held responsible for this, as it seems improbable that evaporation in the Bay of Fundy is nearly sufficient to counterbalance the influx of fresh water.

Helland-Hansen remarks that the high surface temperature shown by his curves "is principally due to the absorption of heat rays from the sun. In places the water is heated by contact with warm air, but this source of heat is of less importance, *the temperature of the surface water being, as a rule, higher than the temperature of the air*."[2] He makes no mention of the time of day at which his readings were made, which, of course, would greatly affect the air temperature—unless he refers to the mean air temperature of the day. All our observations, practically, were made in daylight, and in no case was the air less than 2.2° warmer than the surface water, while in most cases it was considerably more. It may be noted in passing that although three of Helland-Hansen's four stations mentioned above are farther north than the Bay of Fundy, and all four are in the open Atlantic, his lowest surface temperature (that in the Faroe-Shetland channel) is 13°C.—more than 1° higher than the highest reading obtained in the Bay of Fundy. In looking over the records of the *Challenger* observations[3] in July, 1873, it is found that at 6 a.m. on the 16th of the month the air temperature was as much as 3°F. below that of the surface water in the harbour of Madeira; but in the majority of cases the air was warmer than the surface water. On the 15th the mean air temperature was 0.1° F. less than the mean surface water temperature, and on the 26th it was 0.5° F. less, but such cases are considerably in the minority. In May, 1873, when the *Challenger* was in this part of the Atlantic, only in a few cases again did the water temperature exceed the air temperature; and in no case was the mean surface water temperature for the day higher than the mean air temperature, until the 22nd of the month, when the ship had gone south to about the 40th parallel of north latitude.

The temperature curves for stations I to IV do not show so clearly as did those of 1914 the resemblance between stations II, III, and IV, and the distinct difference from these of station I. The curve for station I shows a peculiar rise in temperature between 40 and 70 fathoms. A similar, though smaller rise occurs at the same depth

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[1] Report on the Specific Gravity of Ocean Water, observed on board H.M.S. *Challenger* during the years 1873-76." By J. Y. Buchanan, pp. 14 and 16. Report on the Scientific Results of the Voyage of H.M.S. *Challenger*, Phys. and Chem., Vol. I.

[2] "The Depths of the Ocean," p. 225. (The italics are due to the present writer.)

[3] "Meteorological Observations made during the voyage of H.M.S. *Challenger*, 1873-76." Report on the Scientific Results of the Voyoge of H.M.S. *Challenger*, Narrative, Vol. II, 1882.

in station II and is represented in station III also, at a somewhat deeper point. This is evidently the effect of some current and its occurrence both in the Grand Manan Channel (station I) and at the two neighbouring stations in the open Bay would seem to suggest that it is tidal. It is to be regretted that there was not an opportunity to make further observations with a view to elucidating this matter.

It may be noted that in 1914 a similar, though smaller rise in temperature occurred at a depth of 60 fathoms at station II with the tide two-thirds flood, while in the present case it was one-half flood at the same station. At station I, where the irregularity is most marked, the tide was flood, while at the same station in 1914 no such irregularity was found with the tide one-third flood. Thus from the present limited data there is no indication that this condition occurs regularly at any particular state of the tide. A similar rise is to be seen at a depth of 20 fathoms at station IX (fig. 9).

B. Profiles.

The profile for the section from East Quoddy Head to Petit Passage (fig. 16) shows no marked disagreement with that obtained in 1914. The cold water along the slope from Grand Manan found in 1914 does not appear in the new section. As before, the temperatures tend to be a little higher on the Nova Scotia side of the bay than on the New Brunswick side.[1] The irregularities showing in the graphs, which were discussed in the previous section are not represented in the profile.

The water below 6°C. occupying most of this profile does not appear in that of the St. John to Digby section (fig. 17), and a similar position but less space is occupied by the water between 6.38° and 7°. The tendency of the water towards the Nova Scotia side to be warmer does not appear in this section.

The profile from Quaco Head to Port Lorne (fig 18), shows that the water below 7° has disappeared, and its place, though much less space, is taken by water between 7.9° and 8°. From these three profiles it is easy to picture each successive layer of cold water running up the bay and gradually diminishing in extent until it finally disappears, its place being taken by the next layer. Of course, these remarks are not to be taken as meaning that the water is believed to be actually divided into distinct layers behaving thus.

The longitudinal section from Cape Chignecto to station III (fig. 19) shows that the layers do not simply taper and fade away, but end rather suddenly, clearly suggesting that the water flows up the bay and the lower layers are continually retarded by friction with the bottom, though this appearance is probably due to tidal action. A peculiar condition appears between stations VII, X, and XII. The presence of warmer water at station VII might be attributed to warm water coming in from the Atlantic surface, passing along the south shore, and turning north about this region (see fig. 20), but the source of the cold water at station X is not so clear. It seems possible that as the warm surface water is turned north across the bay (fig. 20) the cold water below goes on up the bay and so comes to the surface. It is most unfortunate that there was not time to make a complete transverse section through station X. Presumably the condition will be due to tidal action, but just how it is produced is not evident in the present state of our knowledge.

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[1] I am informed by Dr. A. G. Huntsman that observations taken during the summer of 1916, nearer the shore on each side, showed this much more markedly, so that the isotherms should really dip quite rapidly near the coast in this profile. His observations appear to indicate a current entering at the mouth of the bay and passing up the Nova Scotia side, producing a corresponding current in an outward direction on the New Brunswick side. A somewhat similar condition, with peculiar tidal changes, was demonstrated in the St. Croix River by Craigie in 1914. (Craigie, E. Horne. "Hydrographic Investigations in the St. Croix River and Passamaquoddy Bay in 1914." Contributions to Canadian Biology, 1914-1915.)

C. *Horizontal Distribution of Temperature.*

In the hope that more light might thereby be thrown on the subject, three maps have been constructed, showing the distribution of temperature in the surface water (fig. 20) and at depths of ten fathoms and thirty fathoms respectively (figs. 21 and 22). As pointed out above, figure 20 shows an indication of an influx of warm surface water, which passes along the south shore and then turns across the bay (see foot note on page 131). If this represents a current in this direction, however, the deeper water should be colder than on the other side, as it must come in from the cold Labrador current, and we have already seen that the results both seasons tend rather the other way. Figures 21 and 22 show no sign of such a circulation, but rather combine with the four profiles to indicate a simple tongue of cold water up the middle of the bay. The cold area on the slope of Grand Manan in the 1914 profile especially supports this. There is nothing at ten fathoms corresponding in any way to the area of colder water appearing at the surface of station X (8·46° surface temperature) and points east of it, nor does the conformation of the shore appear to suggest any satisfactory explanation. That proposed at the end of the previous section appears to be the only one at present. The isolated area of warmer water east of Grand Manan (station II) in fig. 20 does not seem to be explicable on the basis of the present data either. The probable position of the 10°C. isotherm along the north shore is indicated by a broken line, although, of course, there are not sufficient data to locate this properly.

DEDUCTIONS FROM DATA OBTAINED IN ST. MARY BAY.

From the data obtained in St. Mary bay (table II) a plan of the distribution of temperature in the surface water of that bay has been drawn (fig. 23). It shows a rather uniform arrangement with gradually increasing temperature as one passes up the bay from Petit Passage, the shape of the isotherms suggesting that there may be a current up each side with a reverse current down the middle. Immediately below Petit Passage the effects of the tremendous tidal currents through that channel are visible, producing a rather complicated arrangement of the isotherms, due apparently to several interfering cross-currents. The arrangements of the water must, of course, vary very greatly at different states of the tide and the fact that all the observations must be taken at different times makes it improbable that the diagram represents such a condition as ever exists at any one time.

It has been thought worth while also to include a diagram representing a longitudinal section of St. Mary bay (fig. 24), although it must be fully recognized that such a profile, constructed from temperature data taken at the surface and the bottom only, is of a very tentative nature. The figure shows gradual and apparently rather uniform rise of temperature as one passes up the bay, just such as might be expected, the colder area at the surface of station 15 being the only indication of the cross-currents suggested by the surface diagram (fig. 23). No doubt if temperatures at intermediate depths had been taken, more might have been seen. The relations of the cold water appearing at the bottom of stations 13 and 15 are shown by fig. 25, which represents a line carried down the bay from station 13 somewhat farther west than the line in fig. 24. It is seen that this cooler water is spread out sideways from a layer which probably approaches the surface about the mouth of the bay, and occupies almost the whole depth at station 22. It will be noted that, the bay being rather shallow throughout, the temperatures are all comparatively high.

The bottom temperatures in the Annapolis basin (stations 26-33, table II) are peculiar in being much lower in many cases (especially station 31) than any water entering from the river (station 33) or any present in Digby Gut (station 25).

SUMMARY.

This set of observations is a continuation and extension of that made in 1914. The stations have been selected in such a way as to form three transverse sections and

one longitudinal section of the bay of Fundy, thus making it possible to get a fairly clear idea of the temperature distribution in this interesting body of water by examining the profiles constructed and the accompanying diagrams showing the horizontal distribution of temperature at the shallower-levels.

The observations made at the stations where work was carried on in 1914 show little difference in surface temperature, but markedly colder water below. The fact that a seasonal difference of only six weeks makes such a great difference in the temperature of the deep water shows how great is the effect of vertical mixing due to the very great tides. This effect is also seen in the large areas of very uniform temperature found in both years.

The results obtained at stations near the mouth of the bay show an interesting agreement with observations made by Helland-Hansen in the open Atlantic. The statement of this investigator that the temperature of the surface water is, as a rule, higher than the air temperature is not borne out by the Bay of Fundy observations, nor by those of the *Challenger* expedition in this region of the Atlantic.

A slight rise of temperature at an intermediate depth, seen in three stations near the mouth of the bay, gives evidence of deep currents, but no data are available from which definite information concerning these can be obtained.

There is a clear indication that the water on the Nova Scotia side of the lower part of the bay is, on the whole, warmer than on the New Brunswick side, and the plan of the surface temperatures suggests a current of warm surface water from the Atlantic flowing in along the south shore and then turning north about half way up the bay, so that its influence is not visible in the higher profiles. All the other evidence, however, indicates a simple tongue of cold water up the middle of the bay.

Several points with regard to the surface temperatures remain unexplained.

The plan of distribution of temperature in the surface water of St. Mary bay shows a rather uniform increase of temperature in the upper part of the bay, with indications of certain currents and tidal disturbances. The longitudinal profile, which is based upon insufficient data, gives no suggestion of any peculiar or striking conditions.

In conclusion, it remains only to express our indebtedness to Dr. Philip Cox, who accompanied us on both cruises, and Mr. J. R. McMurrich, who joined the party on the second, as well as to Dr. A. B. Macallum, Dr. C. C. Benson, and Dr. A. G. Huntsman for valuable assistance and criticism. We are also deeply indebted to Professor Vachon, Laval University, for the trouble he took in re-titrating the water samples.

TABLE I—Temperature Records for Bay of Fundy Stations in 1915.

Station.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Date	July 14	July 14	July 13	July 13	July 31	July 22	July 22	July 22
Time	12.30 P.M.-1 30 P.M.	9.45 A.M. 11.00 A.M.	6.00 P.M. 8 00 P.M.	3.45 P.M. 4.40 P.M.	10 25 A.M. 11 30 A.M.	9.00 A.M.-10 30 A.M.	11.15 A.M 12 30 P.M.	1.30 P.M.-3.00 P.M.
Bottom	Sand.	Mud.	Mud.	Sand & hard.	Gravel.	Shells.	Coarse gravel.	Shells.
Depth	81 F.	64 F.	114 F.	83 F.	55 F.	43 F.	55 F.	48 F.
Tide	Flood.	½ Flood.	Ebb.	¾ Ebb.	⅓ Flood.	¼ Ebb.	⅙ Ebb.	⅙ Flood.
Air Temperature	16 10°	13·90°	14 25	16·20°	13·70	14·66°	17·95°	15·75°
Temperature at Surface	9 86°	11·69°	10 61°	11 38°	10·41°	10·10°	12·33°	12·68°
" " 5 F	8 07°	7·49°	9·7	9·5	7·79°	9 27°	10 15°	11·13°
" " 10 F	7 55°	7·47°	6 2°	8·3°	7·15°	7·96°	7 88°	7·17°
" " 20 F	7·15°	6·00°	6·12°	7·7°	6·80°	7·39°	6 70°	7·11°
" " 30 F	5 74°	6·00°	5·59°	7·1°	6·77	7·30°	6·51	6 80°
" " 40 F	5·73°	5·64°	5·59°	6·2	6·70°	7·03°	6 42	6·79°
" " 50 F	6·26°	5·79°	5·59°	5·81°	6·71°	......	6·38°	6·77°
" " 60 F	6·08	5·63°	5 59°	5·78	......	......	......	......
" " 70 F	5·72	......	.	5·76°	......	......	......	......
" " 75 F	.	......	5 70	......	......	......	......	......
" " 80 F	5·73°	......	......	5·77°	......	......	......	......
" " 90 F	......	......	5 64°	.	......	......	......	......
" " 100 F	.	......	5 64	......	......	......	......	......
" " 114 F	......	......	5·66°	......	......	......	......	......

Station.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.
Date	July 22	July 28	July 28	July 28	July 27	July 27	July 29
Time	4.00 P.M.-5.15 P.M.	8 30 A.M. 9 15 A.M.	11.20 A.M. 12.15 P.M.	10.00 A.M. 11.00 A.M.	10 60 A.M. 11 30 A.M.	8.25 A.M. 9 30 A.M.	12 15 P.M. 1.10 P.M.
Bottom	Rock.	Coarse gravel.	Sand.	Rock.	Sand & hard.	Rock.	Sand.
Depth	47 F.	47 F.	39 5 F.	36 F.	41 F.	35 F.	34 F.
Tide	½ Flood.	⅓ Flood.	⅝ Flood.	½ Flood.	⅝ Flood.	⅓ Flood.	⅚ Flood.
Air Temperature	14·75°	12 93	14·73°	14·76	11 92°	15·39°	12 34°
Temperature at Surface	11·71°	8·46°	10·51°	9·20	8·93°	9·56°	10 10°
" " 5 F	8·33°	7 89°	8·95°	8 04°	8·41	8·93°	9·54°
" " 10 F	7·82°	7 90°	8·74°	8·03	8·40°	8·91°	9 54°
" " 20 F	7·95°	7 84°	8 41	7·99	8·43	8·91	9·54°
" " 30 F	7·27°	7 82	8·41°	7·97	8·43°	8·93°	9 54°
" " 40 F	......	7·82	8 44°	7·93°	8·42	......	......
" " 50 F	6·92°	7 81°	......	......	......	......	......
" " 60 F	......	......	......	......	......	......	......
" " 70 F	......	......	......	......	......	......	......
" " 75 F	......	......	......	......	......	......	......
" " 80 F	......	......	......	......	......	......	......
" " 90 F	......	......	......	......	......	......	......
" " 100 F	......	......	......	......	......	......	......
" " 114 F	......	......	......	......	......	......	......

TABLE II.—Temperatures in St. Mary Bay and Annapolis Basin in 1915. (°Centigrade.)

Station.	1.	2.	3.	4.	5.	6.	7	8.	9.	10	11.
Date	July 7	July 7	July 7	July 7	July 7	July 7	July 7	July 8	July 8	July 7	July 13
Time	11.15 A.M.	10.30 A.M.	12.10 P.M.	1.45 P.M.	8.45 A.M.	2.45 P.M.	3.30 P.M.	8.10 A.M.	8.50 A.M.	4.35 P.M.	1.35 P.M.
Bottom	Mud.	Mud.	Mud.	Gravel.	Mud.	Mud.	Shell & sand.	Sand.	Sand.	Sand.	Sand.
Depth	4 F.	7 F.	14·5 F.	15·5 F.	11·5 F.	11·5 F.	9·5 F.	18 F.	18 F.	2·5 F.	17·5 F.
Tide	2/3 Ebb.	1/2 Ebb.	5/6 Ebb.	Ebb.	5/6 Flood.	1/6 Flood	1/3 Flood.	1/6 Ebb.	1/3 Ebb.	1/2 Flood.	1/6 Ebb.
Air Temperature	..	..	..	15·60°	....	15·62	15·35°	13·85°	15·00°	14·05°	14·35°
Surface Temperature	14·80	13·78	13·92	13·95	13·95	13·52	12·90°	12·98	12·79	11·39	11·96°
Bottom Temperature	13·40	11·82	11·61	11·37	10·54°	10·36°	10·22	9·03°	8·68	10·77	9·29°

Station.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
Date	July 8	July 13	July 8	July 8	July 8	July 13	July 13	July 13	July 13	July 13	July 13
Time	10.20 A.M.	1.00 P.M.	10.55 A.M.	11.45 A.M.	12.25 P.M.	11.15 A.M.	9.45 A.M.	9.00 A.M.	10.30 A.M.	5.40 A.M.	6.55 A.M.
Bottom	Rock.	Sand.	Rock.	Rock.	Rock.	Rock.	Coarse gravel.	Rock.	Sand.	Sand.	Rock.
Depth	14·5 F.	18 F.	19·5 F.	18·5 F.	7·5 F.	26 F.	14·5 F.	6·5 F.	28 F.	23·5 F.	19·5 F.
Tide	1/2 Ebb.	1/6 Ebb.	2/3 Ebb.	5/6 Ebb.	Ebb.	5/6 Flood	2/3 Flood.	1/2 Flood.	3/4 Flood.	Ebb.	1/6 Flood.
Air Temperature	15·58	19·38°	15·80°	15·65°	15·43	15·67°	13·57°	13·30°	13·54°	12·35°	11·37°
Surface Temperature	12·80	11·45	9·57°	10·12°	10·98	10·48°	11·43	11·67°	10·09°	9·28°	9·63
Bottom Temperature	8·29	8·79°	7·81°	8·44	10·07°	8·69°	9·39°	10·90	8·34°	8·06°	8·09°

Station.	23.	24.	25	26.	27.	28.	29.	30.	31.	32.	33.
Date	July 13	July 13	July 23	July 23	July 23	July 24	July 23	July 23	July 24	July 24	July 24
Time	7.40 A.M.	8.15 A.M.	2.30 P.M.	10.15 A.M.	3.30 P.M.	9.05 A.M.	11.15 A.M.	Noon.	10.00 A.M.	10.30 A.M.	11.30 A.M.
Bottom	Gravel.	Rock.	Rock.	Mud.	Mud.	Mud & shell.	Mud.	Mud.	Mud.	Sand.	Gravel.
Depth	15·5 F.	8·5 F.	38 F.	6 F.	11·5 F.	7 F.	3·5 F.	2·5 F.	7·5 F.	8 F.	9 F.
Tide	1/4 Flood.	1/4 Flood.	Ebb.	1/4 Ebb.	1/6 Ebb.	Flood.	1/2 Ebb.	2/3 Ebb.	1/6 Ebb.	1/4 Ebb.	1/3 Ebb.
Air Temp.	13·95	12·09°	16·85	15·57°	18·50	16·32°	17·25	17·95	14·63°	17·76°	18·55°
Surface Temperature	10·22°	10·93°	11·68	11·14	11·92°	9·41°	12·70°	12·52	11·22°	12·31	15·33°
Bottom Temperature	9·17°	10·29°	9·30	9·05°	8·76	8·54°	10·04	11·04°	6·99°	12·19°	13·33°
15 Fathom Temperature	.	......	9·80	.	. . .	.. ... .	....	....	.. ...	.	. . . .

TABLE III.—Specific Gravity, Chlorine Content, and Salinity of Water Samples from Bottom of St. Mary Bay Stations in 1915.

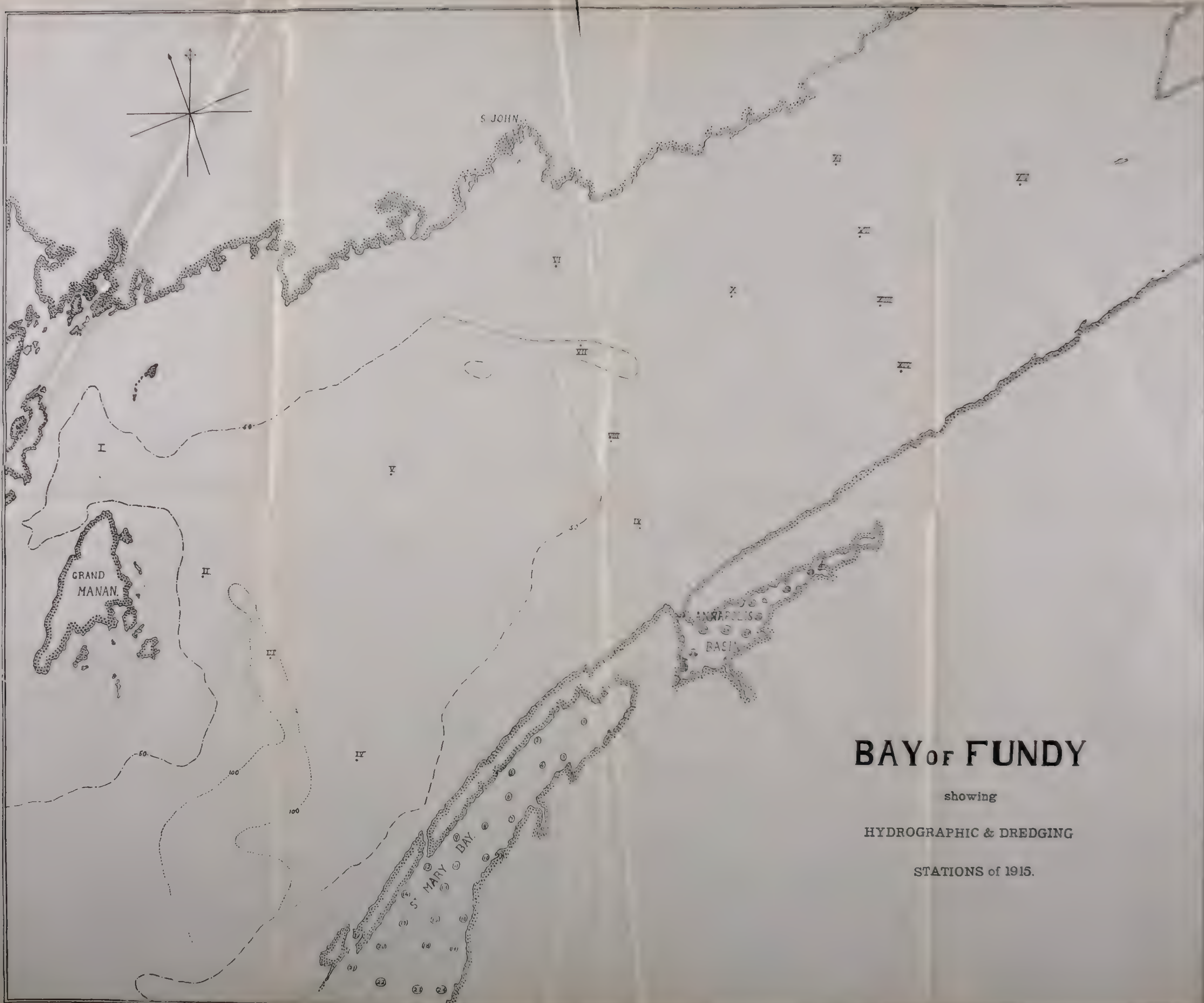
Station.	Sp. Gt. at 15·56° C.	% Chlorine.	% Total Salts.	Station.	Sp. Gt. at 15·56° C.	% Chlorine.	% Total Salts.
1	10243	1·817	3·276	13	10248	1·832	3·304
2		(1·819)	(3·280)	14	10249	1·842	3·322
3	10248	1·825	3·291	15	10249	1·849	3·334
4	10247	1·833	3·306	16	10247	1·840	3·318
5	10247	1.832	3·304	17	10248	1·845	3·327
6	10248	1·835	3·309	18	10245	1·835	3·309
7	10248	1·835	3·309	19	10247	1·855	3·346
8	10247	1·831	3·302	20	10247	1·869	3·370
9	10248	1·842	3·322	21	10248	1·866	3·365
10	10248	1·842	3·322	22	10245	1·861	3·354
11	10246	1·841	3·319	23	10249	1·857	3·347
12	10249	1·836	3·311	24	10248	1·861	3·353

The density of each water sample was determined at room temperature by means of a delicate hydrometer, and corrected to read at 15.56° C. by Buchanan's Diagram.[1] The methods of analysis and of calculating the salinity were those of Dittmar.[1]

[1] Report on the Scientific Results of the Voyage of H.M.S. *Challenger.* Physics and Chemistry, Vol. I, 1884.

J. Y. Buchanan. "Report on the Specific Gravity of Samples of Ocean Water observed on board H.M.S. *Challenger,* during the years 1873-76." Diagram 1.

William Dittmar. "Report on Researches into the Composition of Ocean Water collected by H.M.S. *Challenger* during the years 1873-76." pp. 4 and 40.


S. JOHN
GRAND
MANAN.
ANNAPOLIS
BASIN
S. MARY BAY.
50
100
BAY OF FUNDY
showing
HYDROGRAPHIC & DREDGING
STATIONS of 1915.

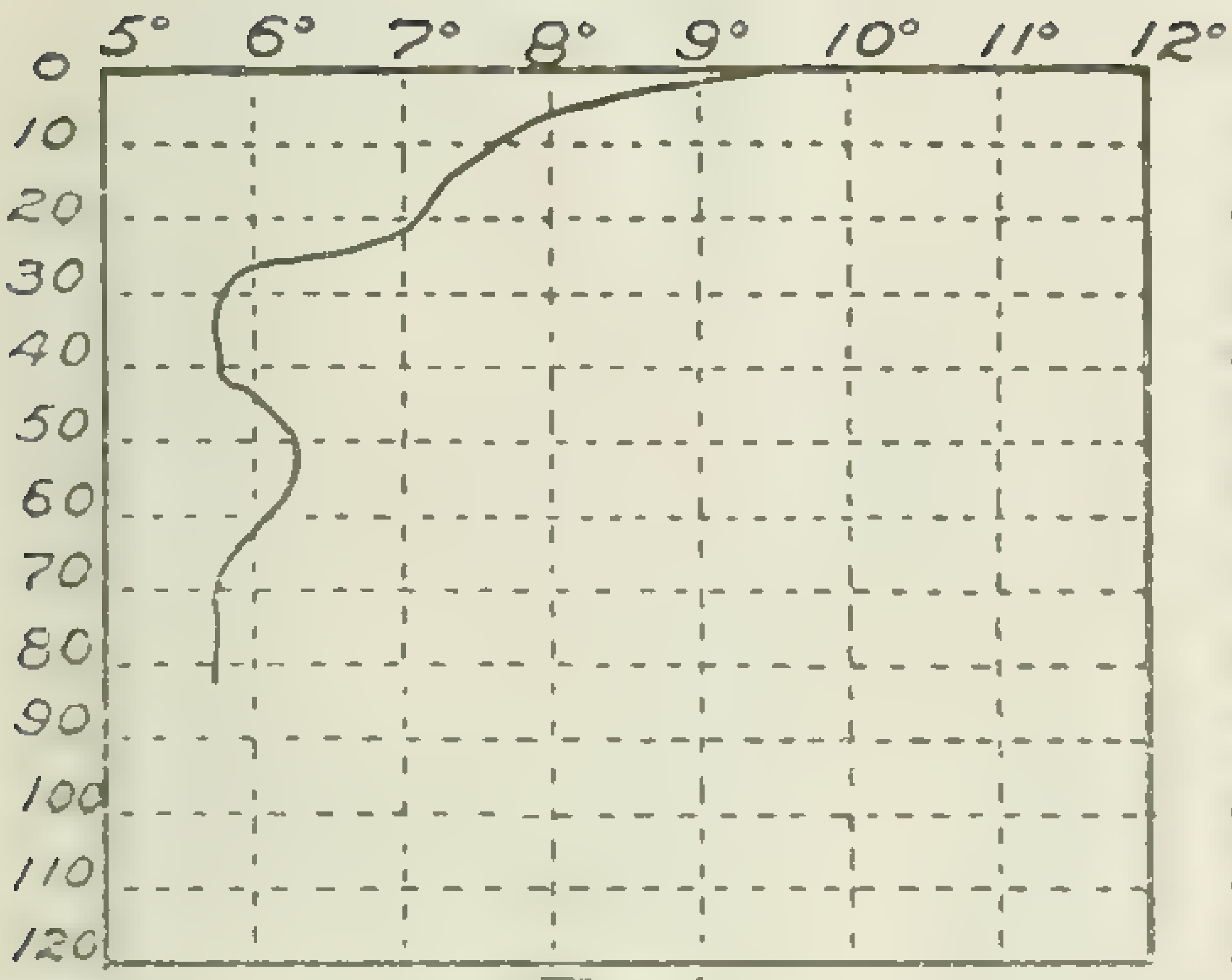


Fig. 1.

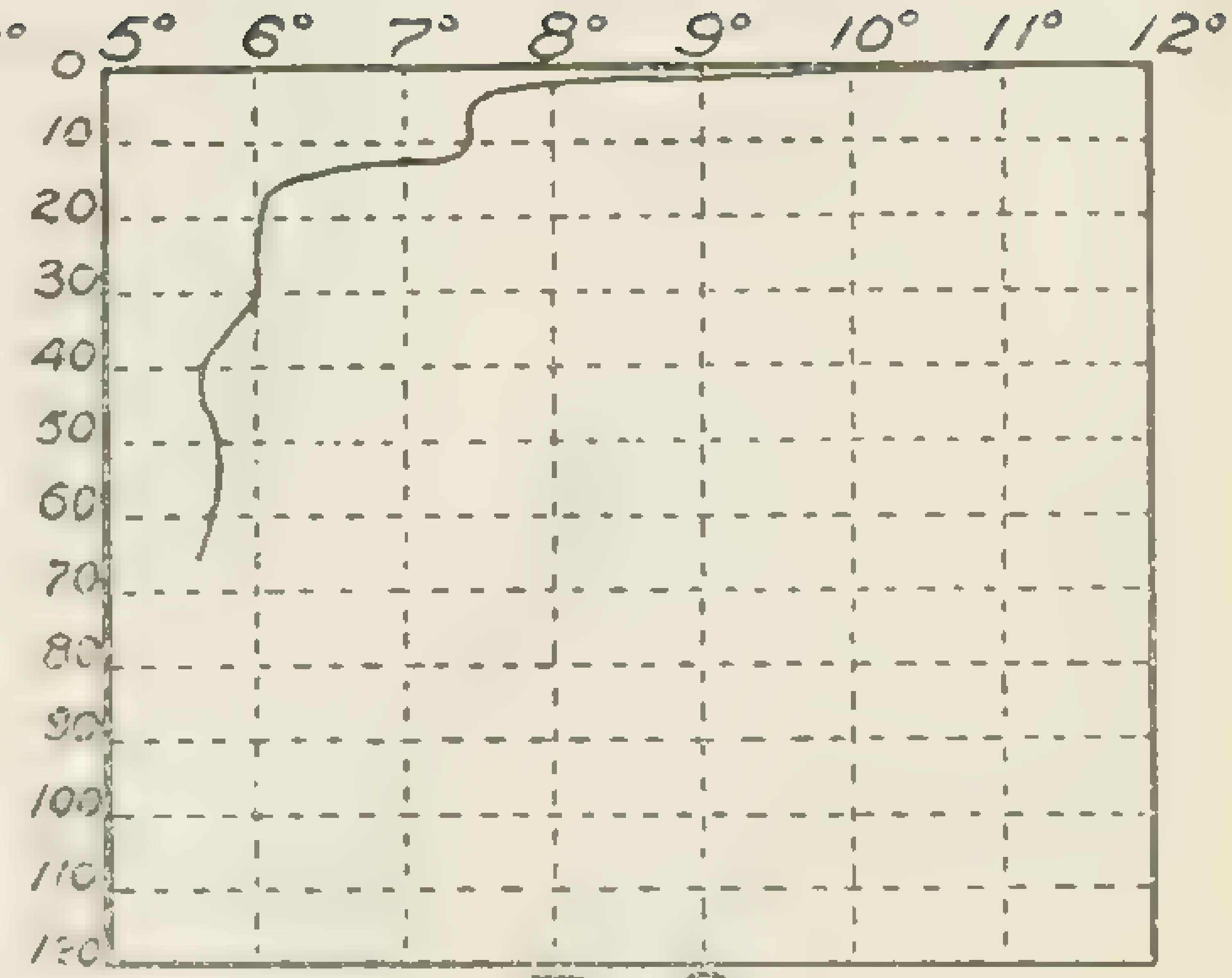


Fig. 2.

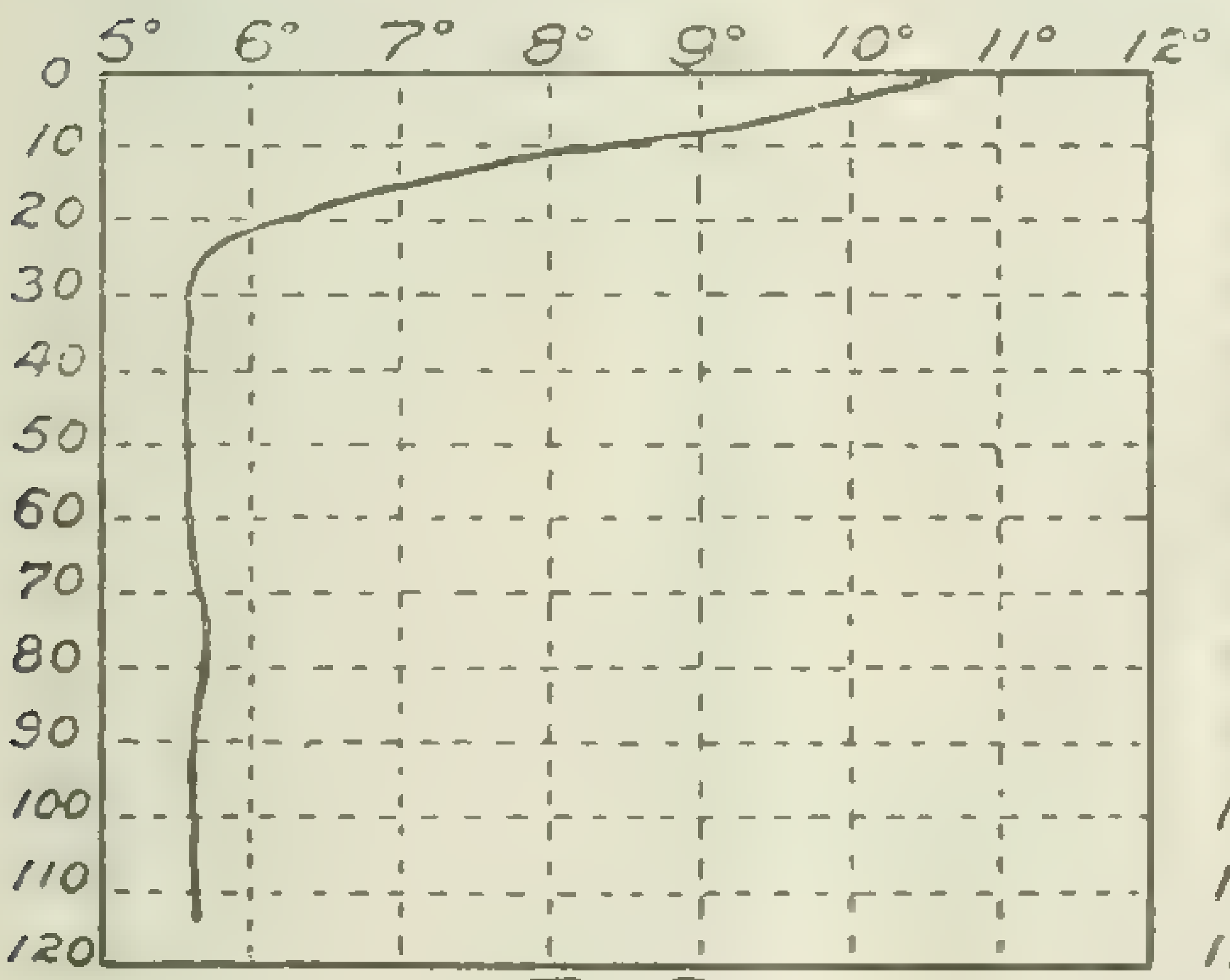


Fig. 3.

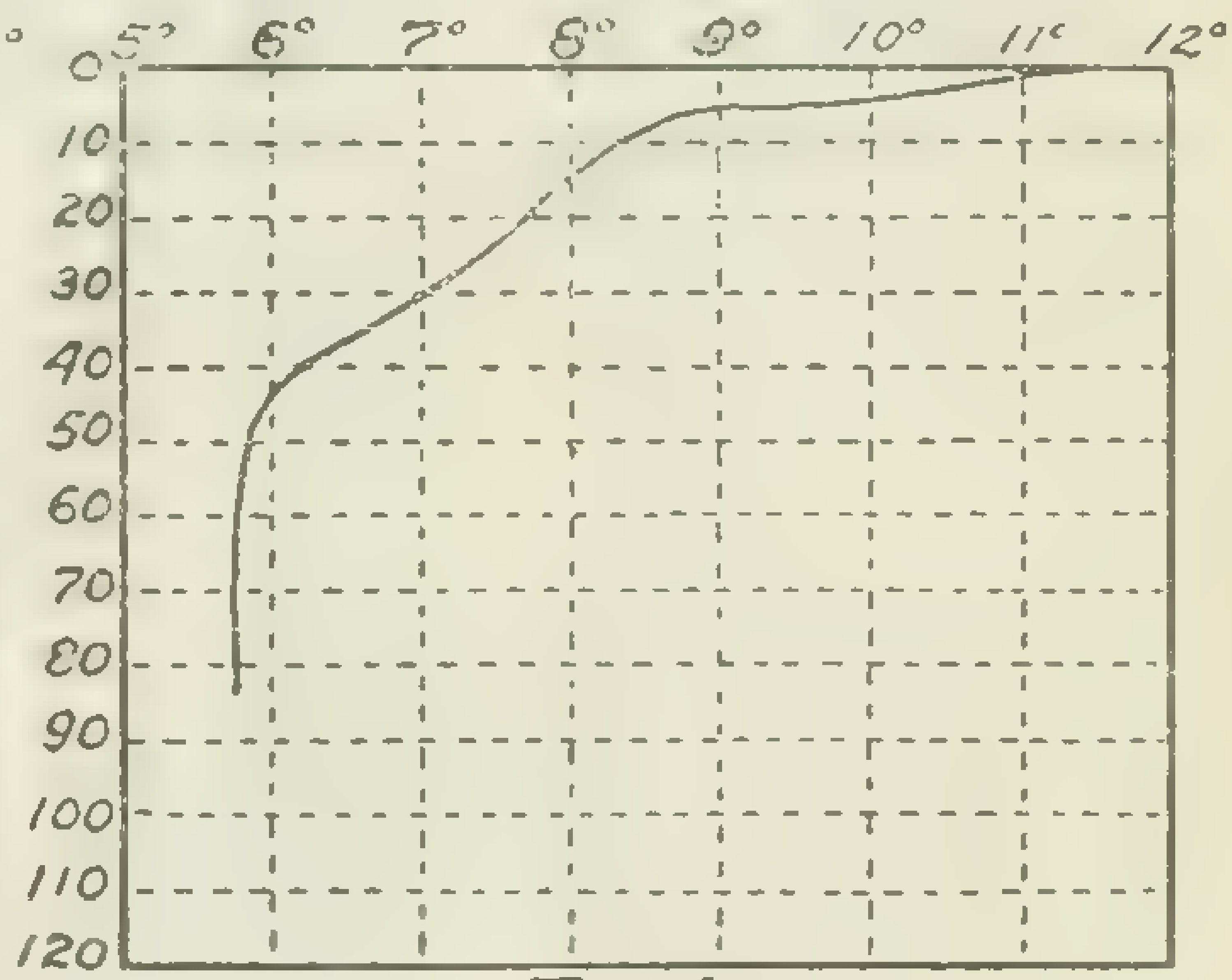


Fig. 4.

Figs. 1–4. Temperature curves for stations I. to IV. respectively.

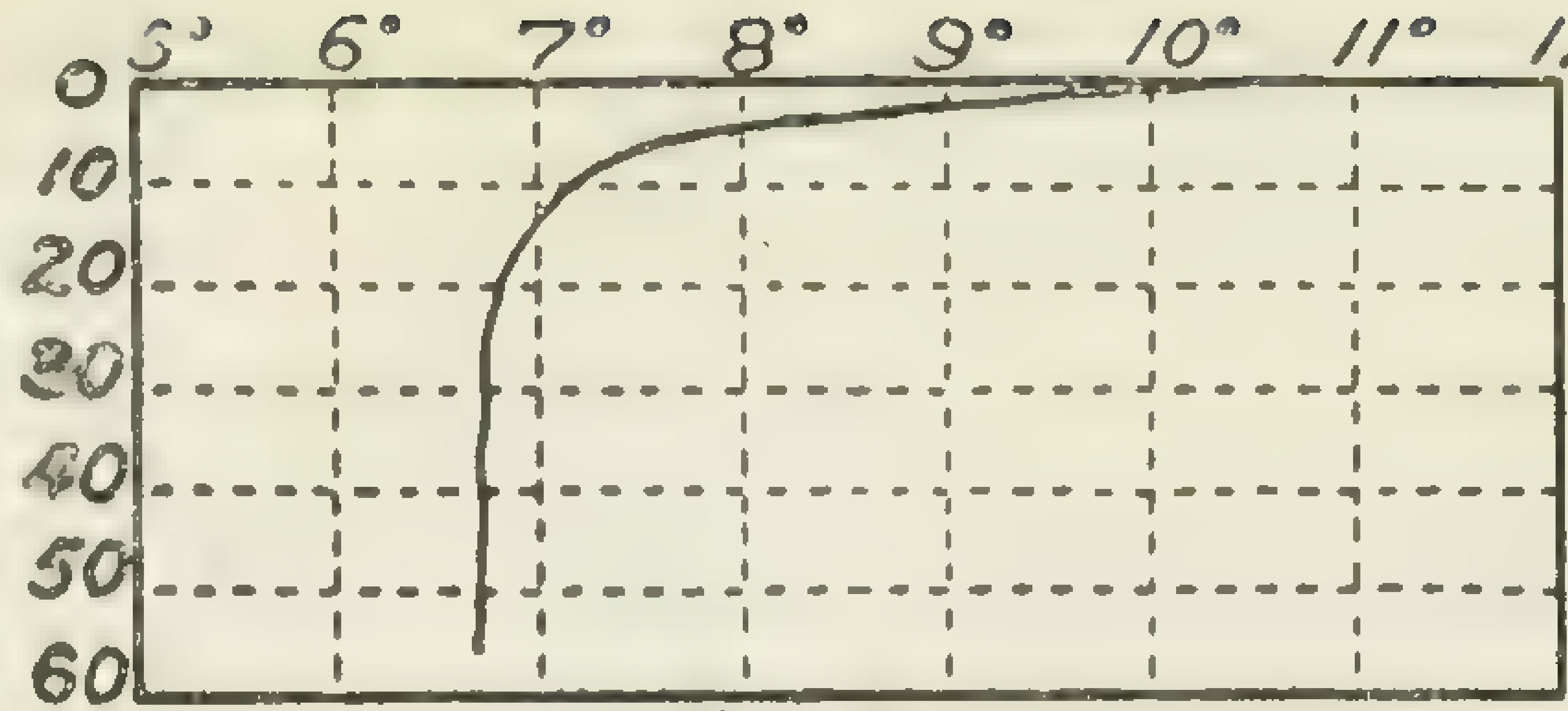


Fig. 5.

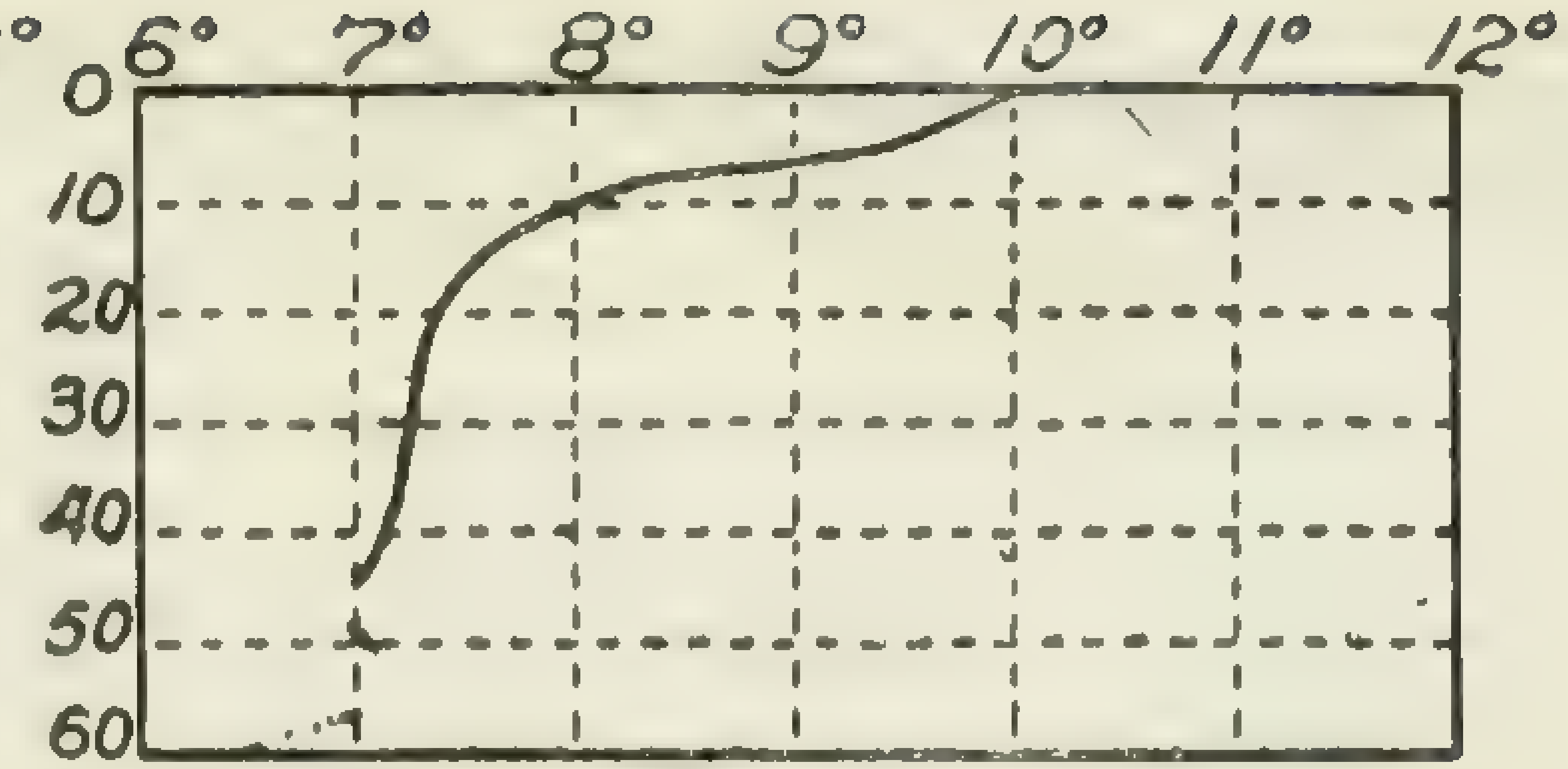


Fig. 6.

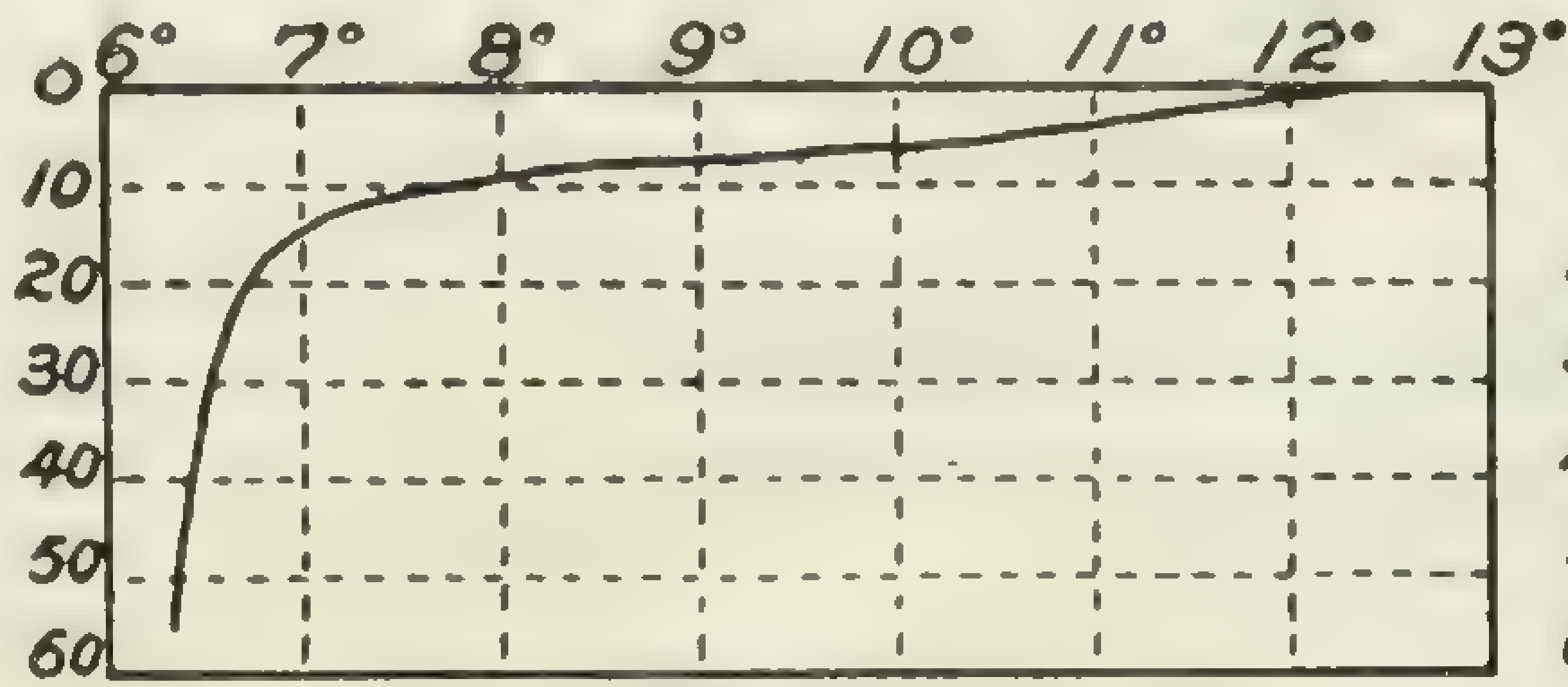


Fig. 7.

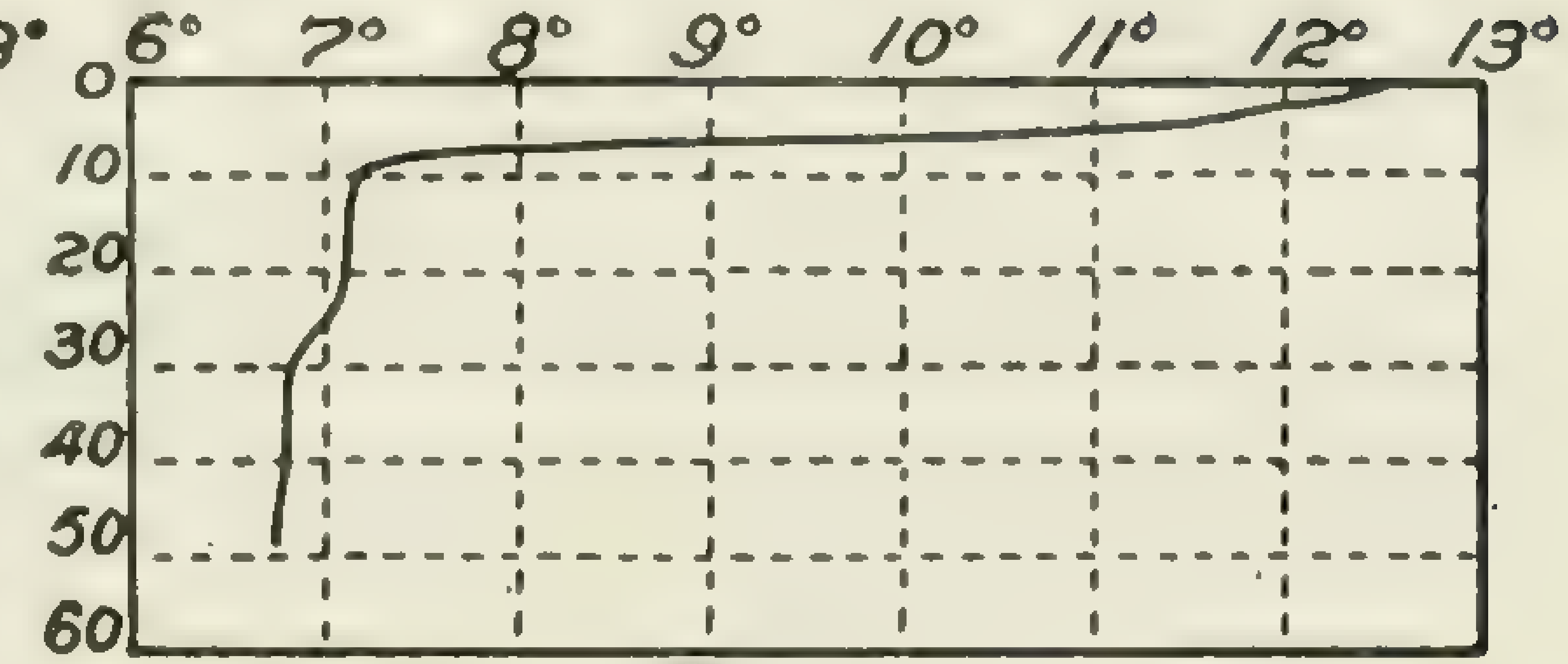


Fig. 8.

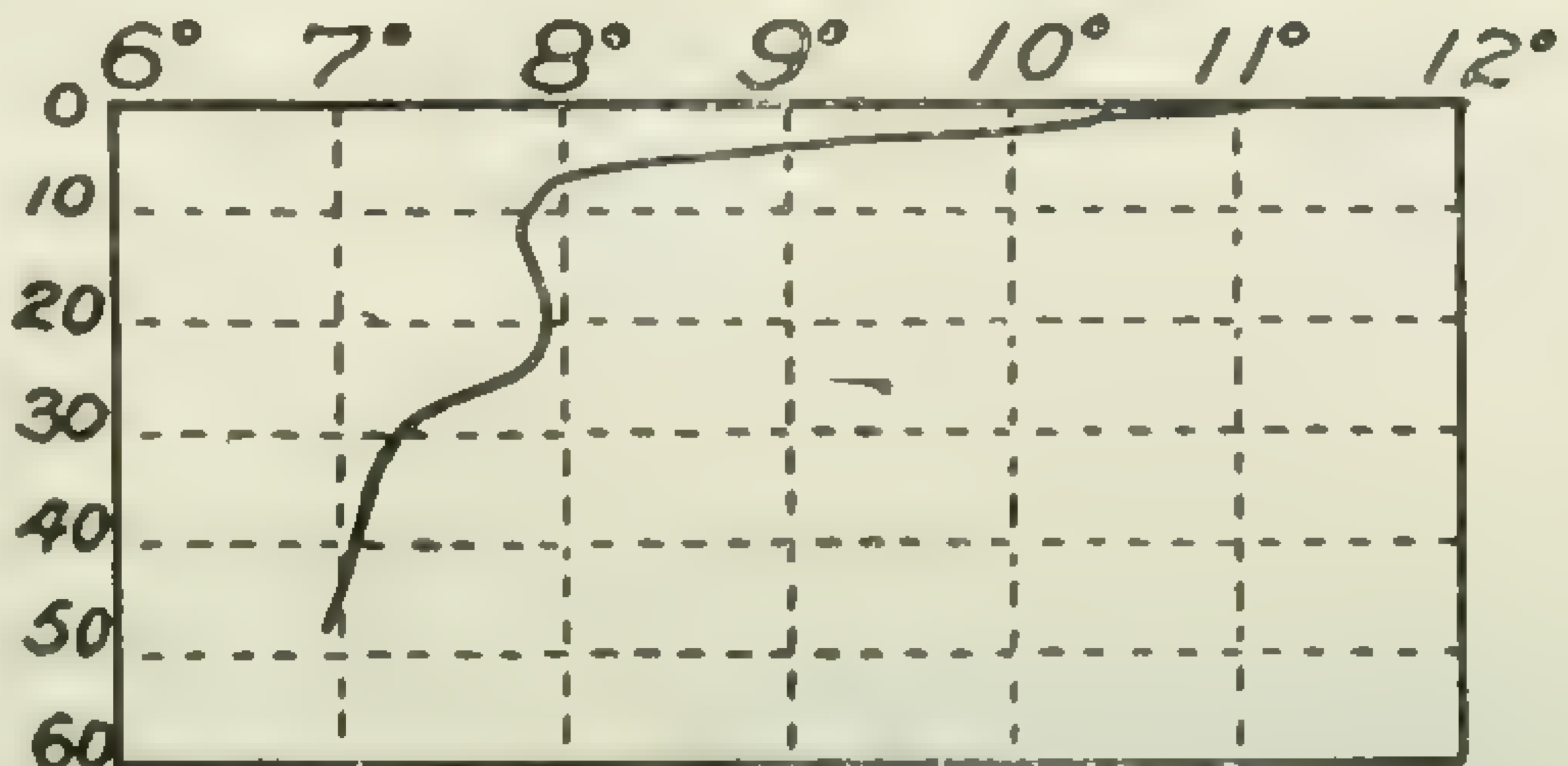


Fig. 9.

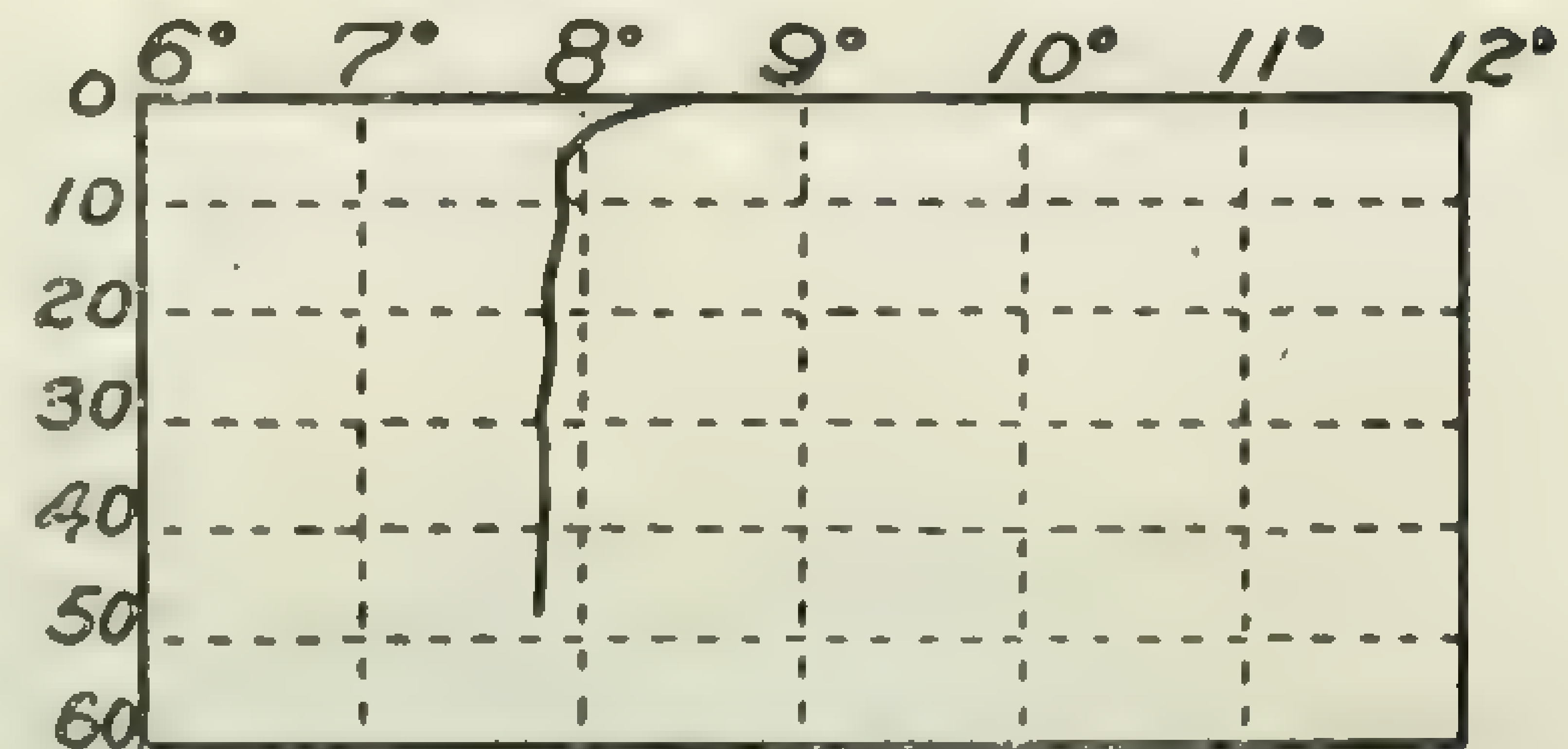


Fig. 10.

Figs. 5-10. Temperature curves for stations V. to X. respectively.

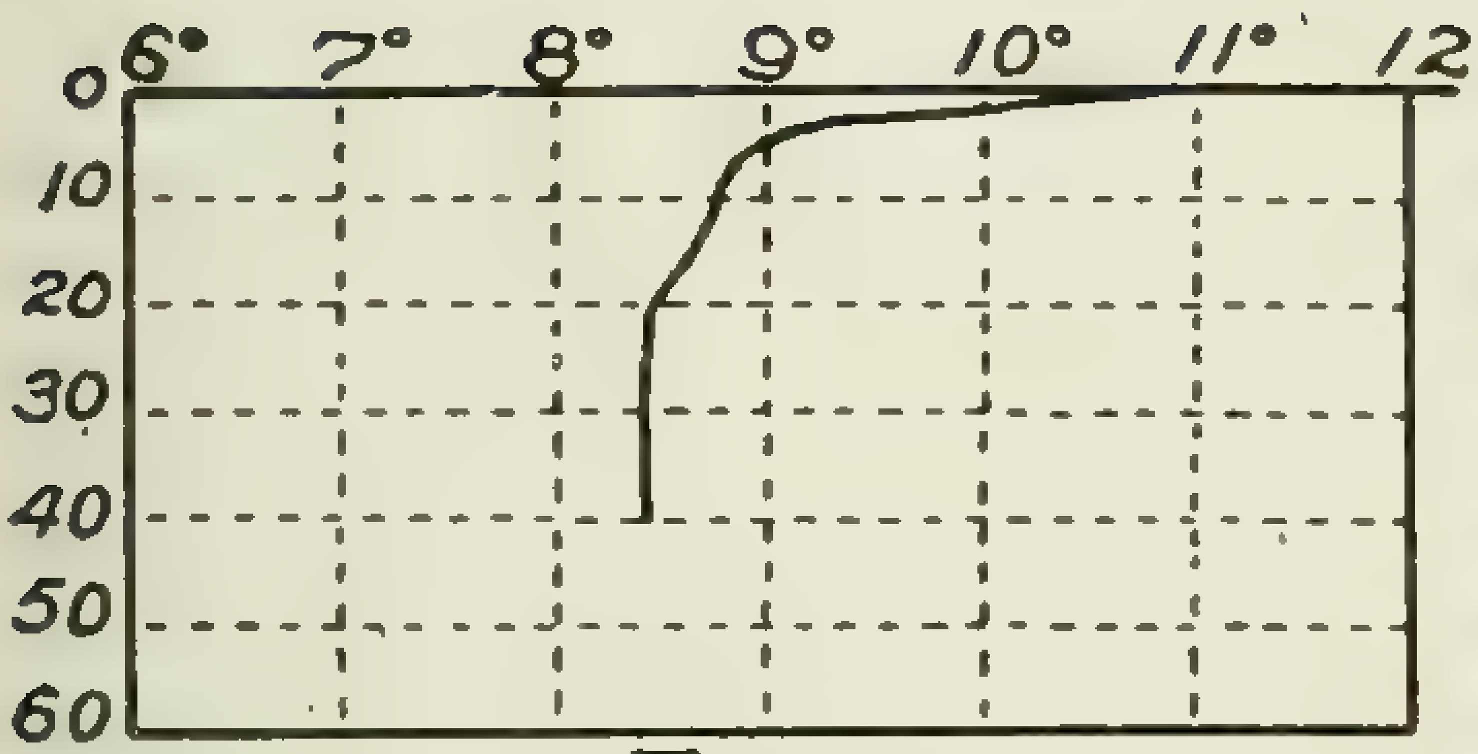


Fig. 11.

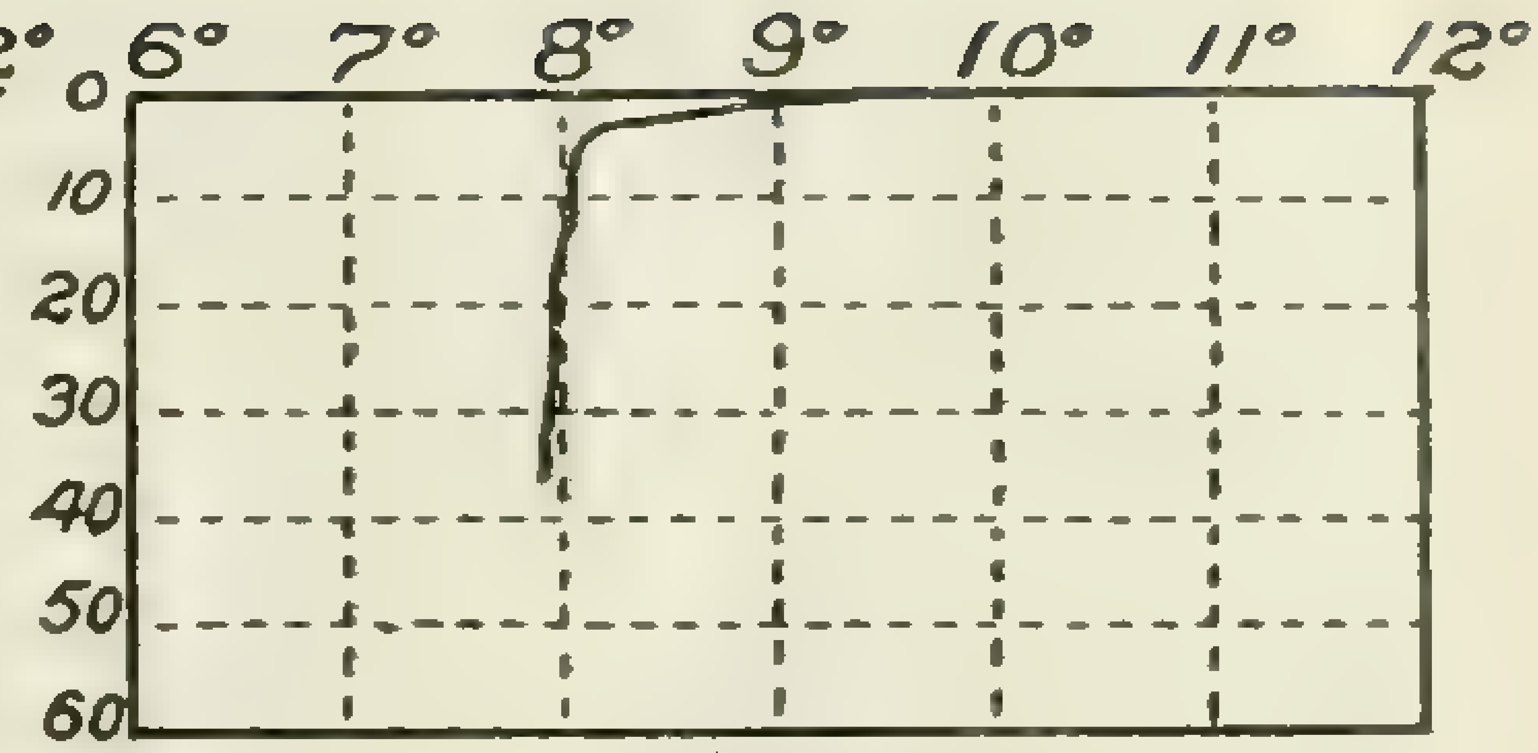


Fig. 12.

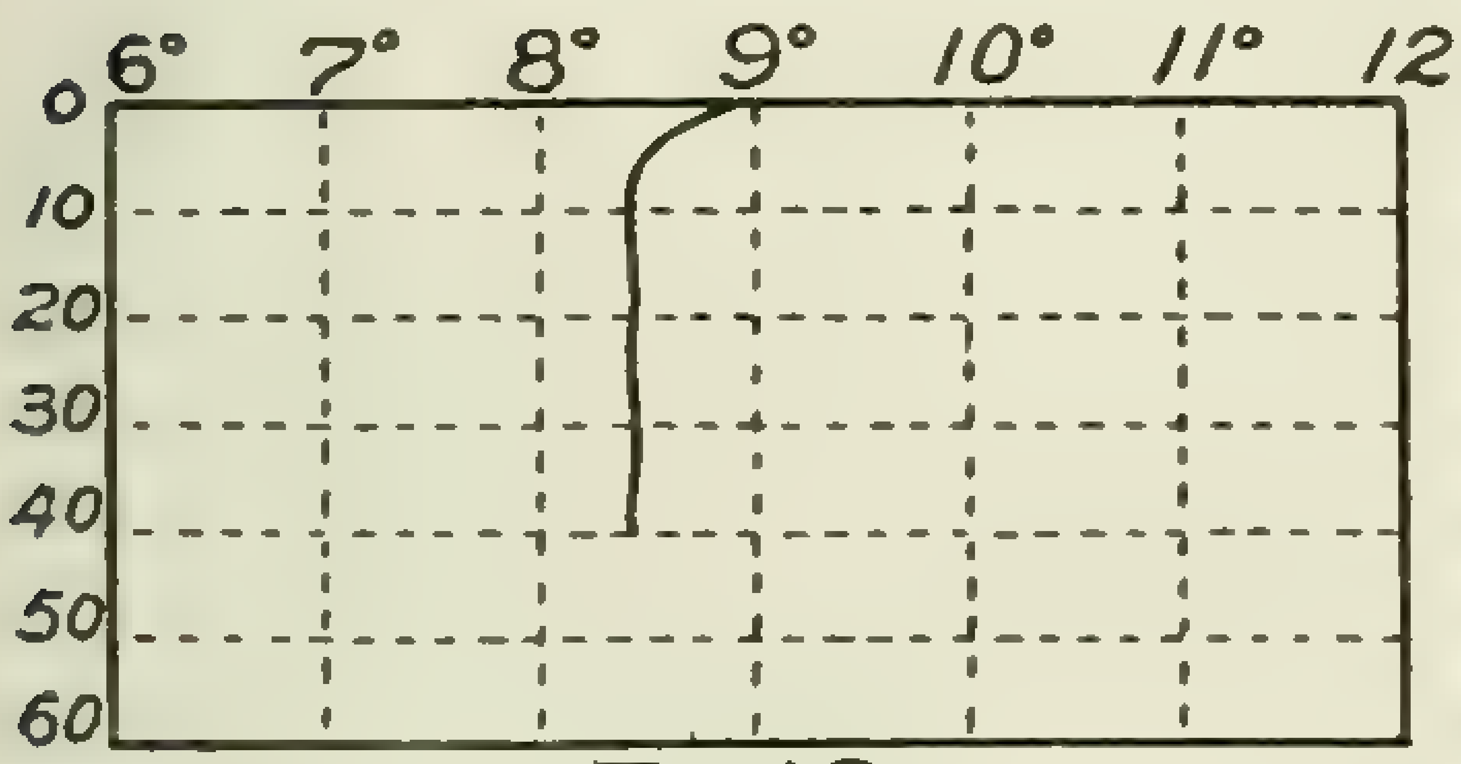


Fig. 13.

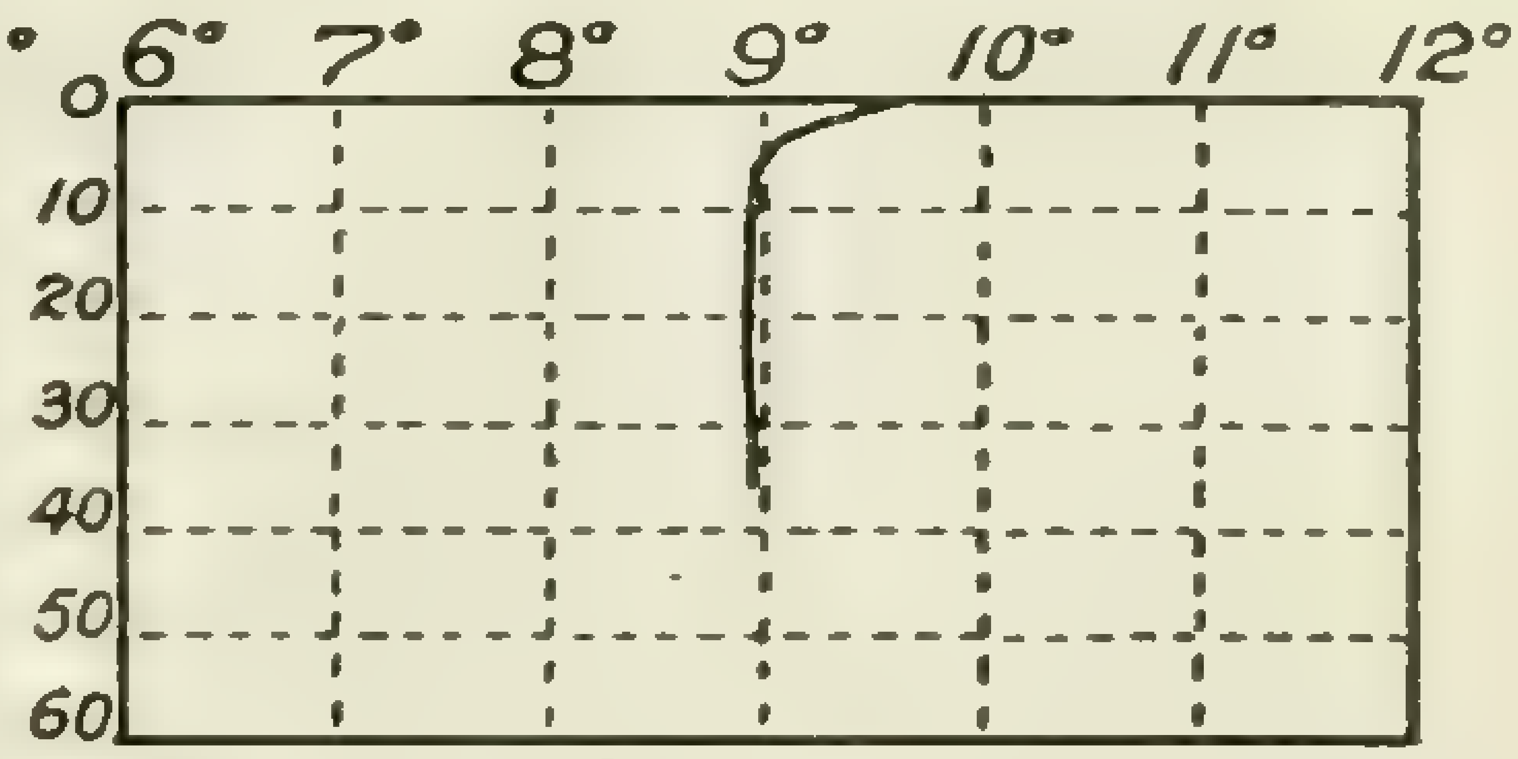


Fig. 14.

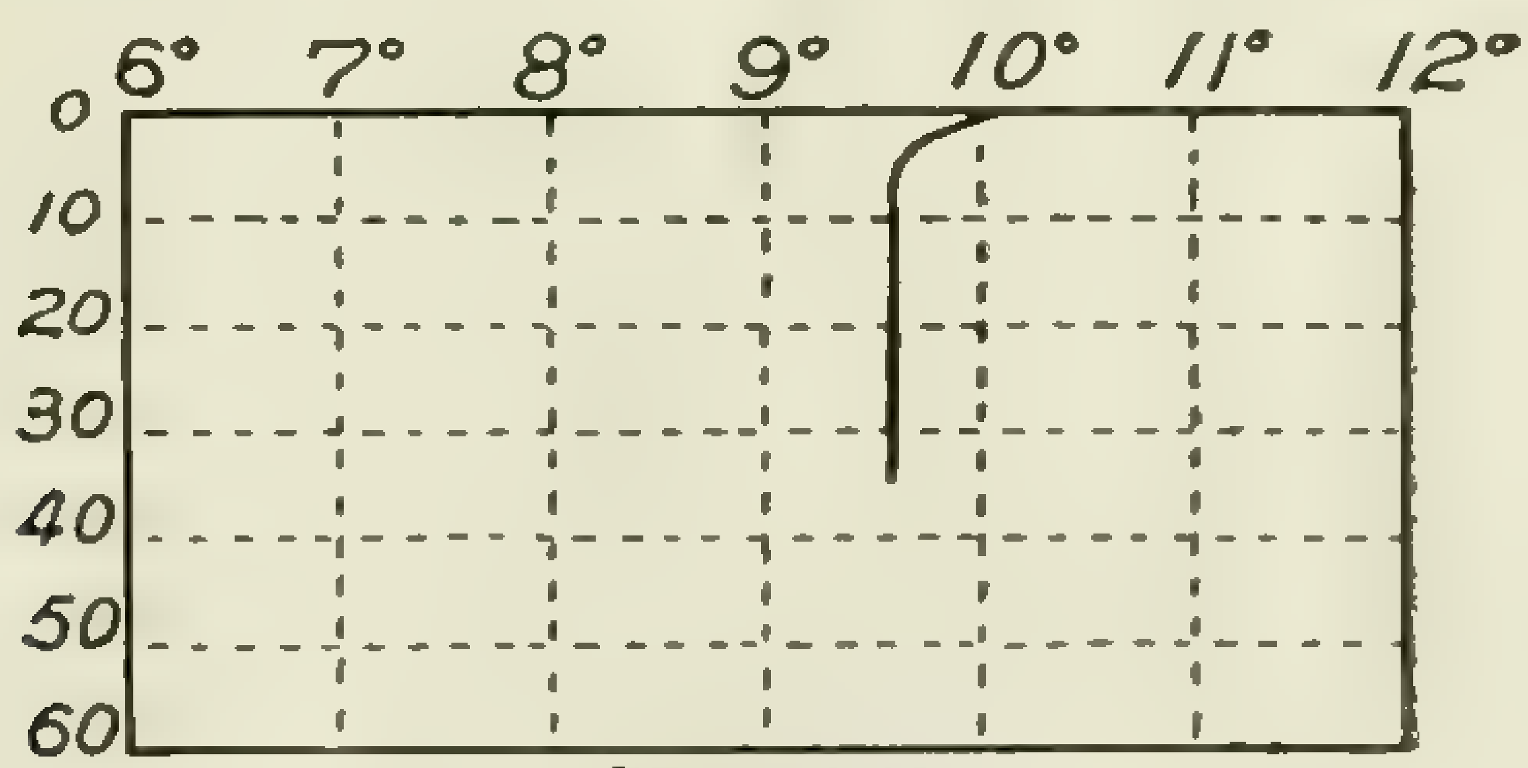


Fig. 15.

Figs. 11-15. Temperature curves for stations XI. to XV. respectively.

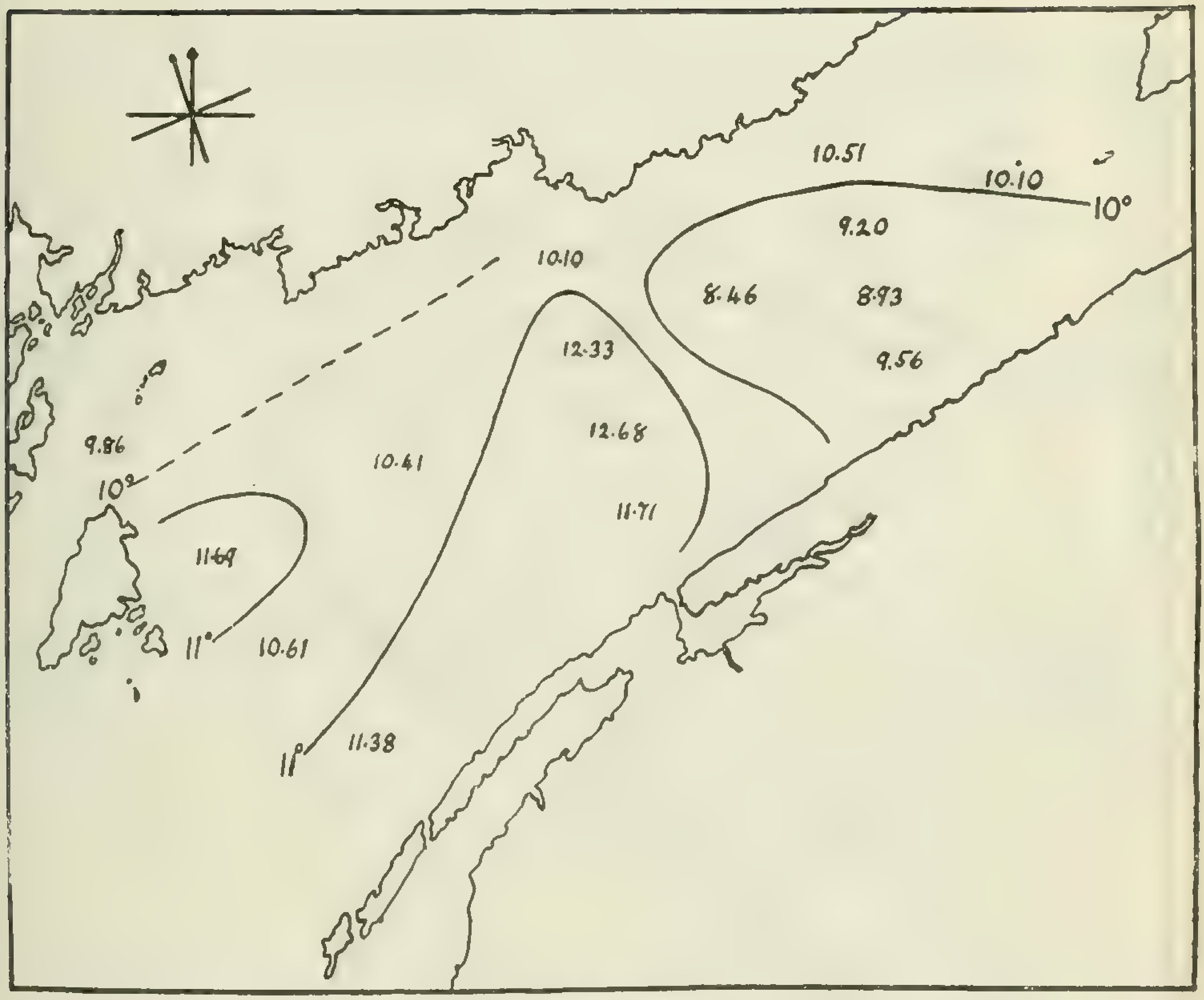


Fig. 20.

Fig. 20. The Bay of Bundy, showing temperatures of the surface water.

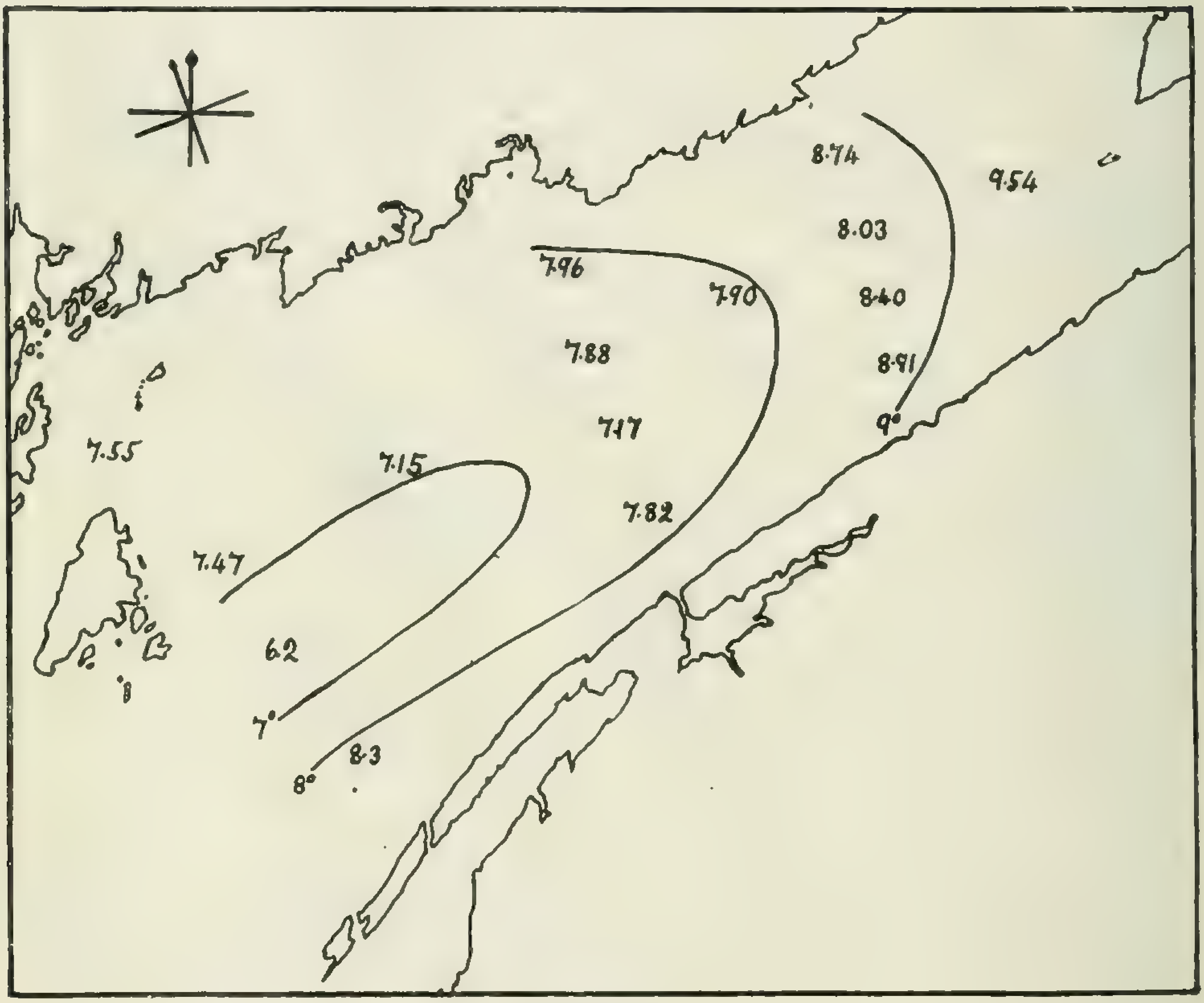


Fig. 21.

Fig. 21. The Bay of Fundy, showing temperatures of the water at a depth of 10 fathoms.

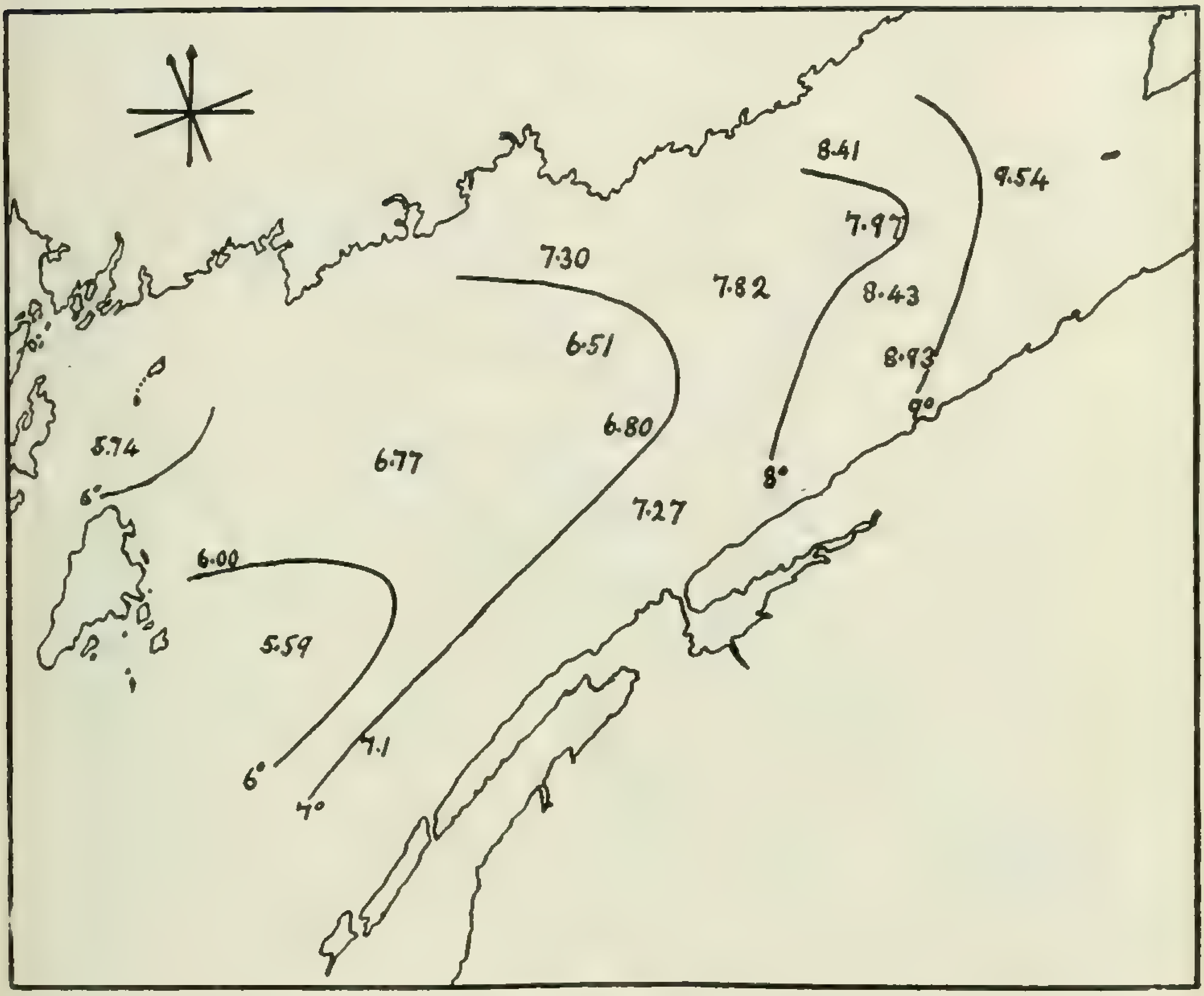


Fig. 22.

Fig. 22. The Bay of Fundy, showing temperatures of the water at a depth of 30 fathoms.

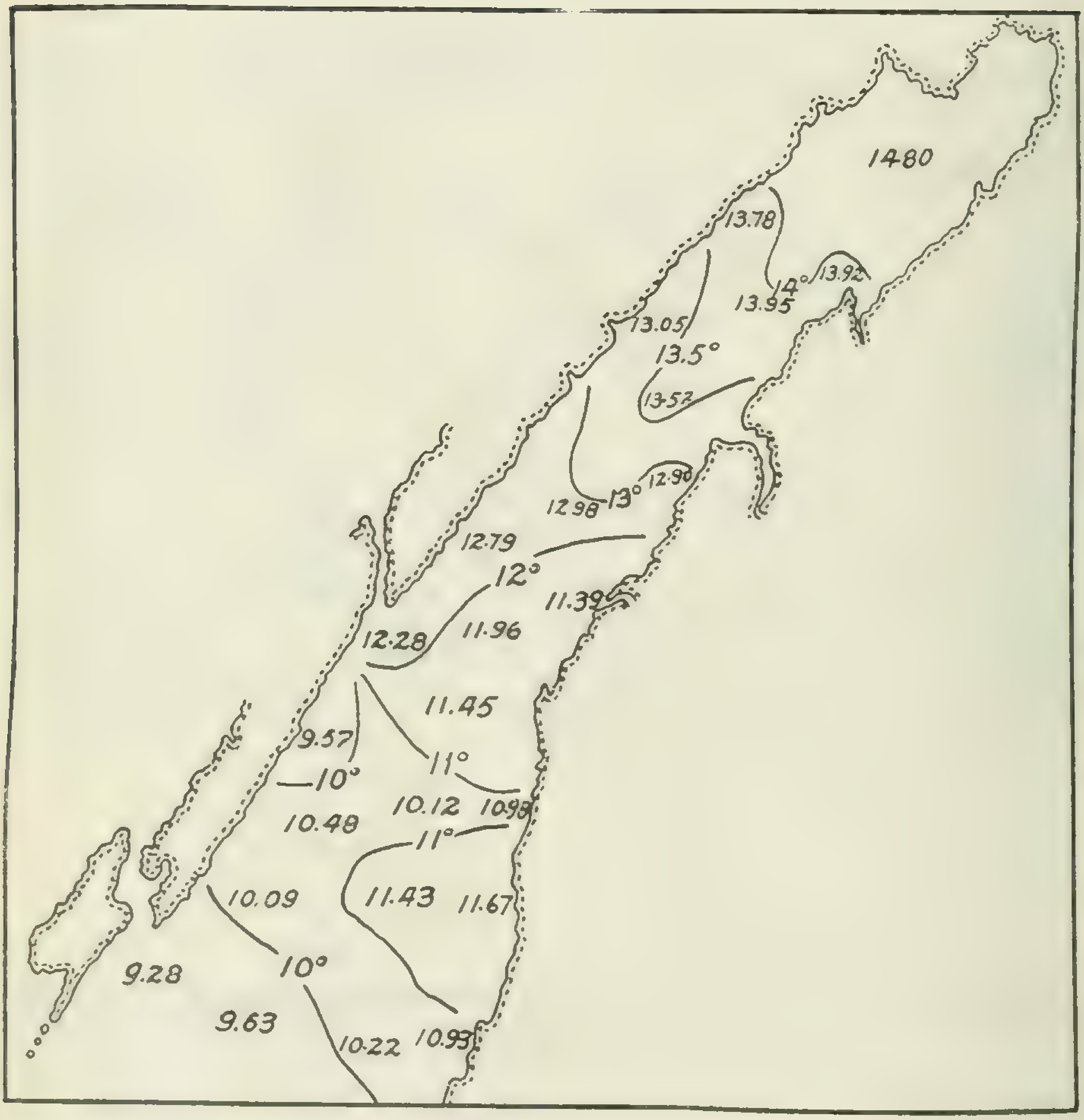


Fig. 23.

Fig. 23. St. Mary Bay, showing temperatures of the surface water.

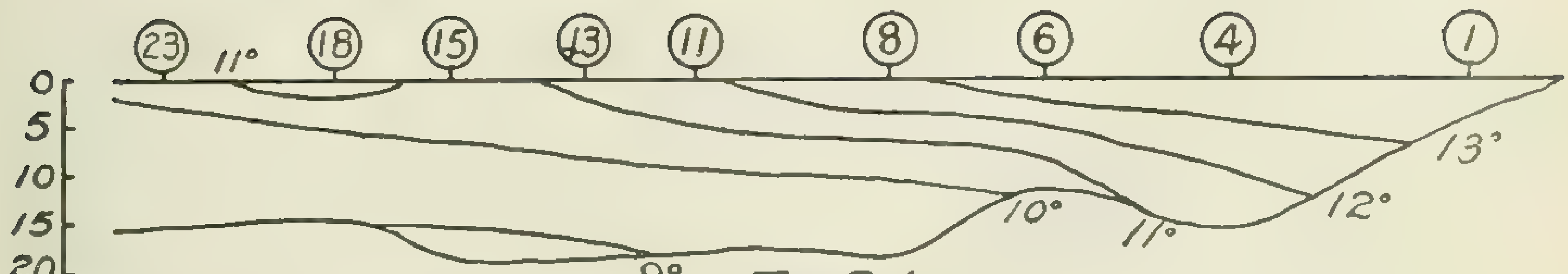


Fig. 24.

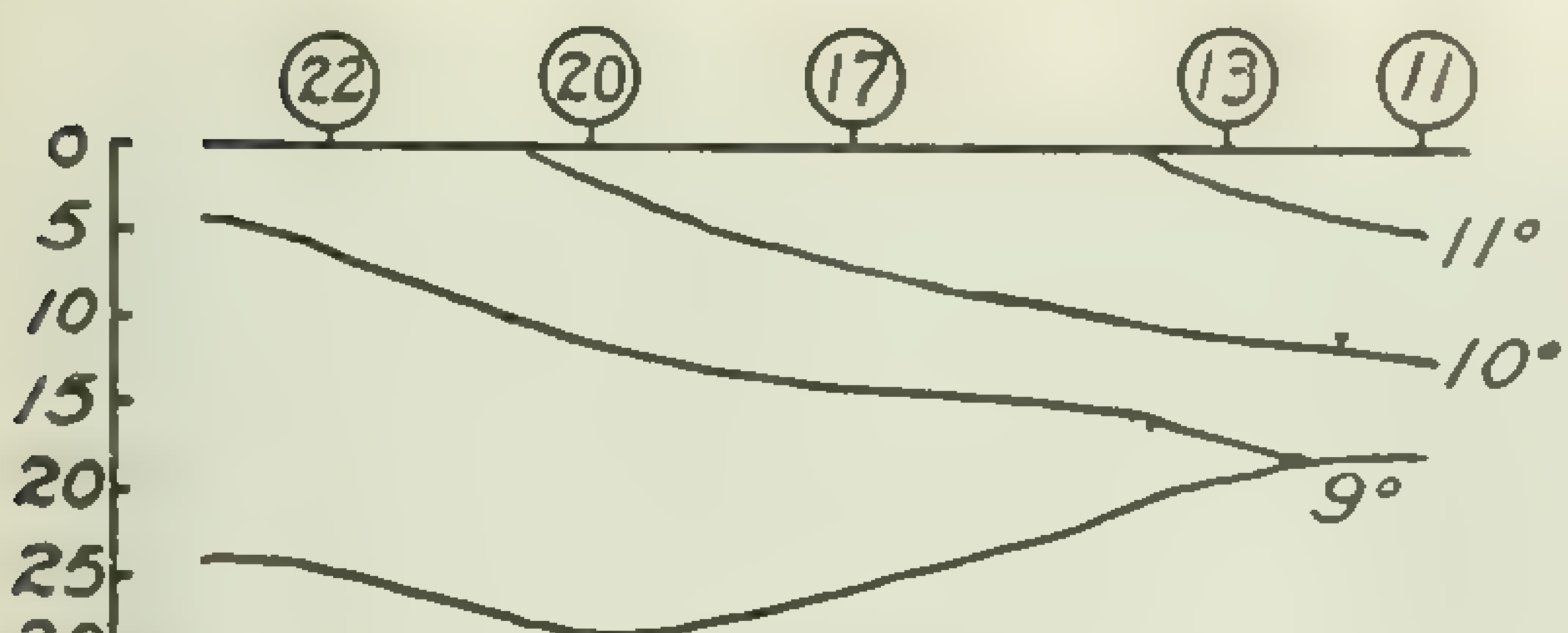


Fig. 25.

Figs. 24 and 25. Longitudinal isothermal profile of St. Mary Bay.

VIII.

EXAMINATION OF AFFECTED SALMON, MIRAMICHI HATCHERY, NEW BRUNSWICK.

By F. C. Harrison, D.Sc., F.R.S.C., etc., Principal of Macdonald College, Ste. Anne de Bellevue, P.Q.

On October 11, 1915, I received a telephone message from Dr. A. B. Macallum, Secretary-Treasurer of the Biological Board of Canada, with reference to a diseased condition of the salmon in the hatchery at South Esk, N.B. He also informed me that Dr. Huntsman, of the University of Toronto, was leaving in order to investigate the trouble, and if I thought it wise to do so I could join him and proceed to the hatchery.

I got into telephonic communication with Dr. Huntsman on his passing through Montreal, and after discussing the situation thought it best to remain at the laboratory to examine the diseased fish that Dr. Huntsman would send me in order that I might investigate the disease, for it seemed better to attempt the finding out of the trouble with all bacteriological facilities to hand, which would have been lacking at the hatchery, and which at that time it was impossible to take there.

Retaining Pond at the Miramichi Hatchery, South Esk, N.B.

On October 14, I received a copy of the letter which Dr. Macallum received from the Deputy Minister of the Department of Naval Service, reading as follows:—

> The officer in charge of the Miramichi hatchery, which is located on the South Esk river, a small tributary of the Southwest Miramichi, recently reported that a disease had broken out amongst the salmon in the retaining pond in connection with the hatchery in which the parent fish are placed and retained

until the spawning time comes around. It happened that the Superintendent of Fisheries was in the Maritime Provinces when this information was received, and I had him instructed to visit the pond and look into the matter.

There were on Tuesday of this week somewhat over 2,400 salmon in the pond, between 300 and 400 of which were affected. The disease takes the form of a fungus. The first indication is the removal of the scales from the back of the neck. They are evidently eaten off. Then a white fungus develops, which rapidly spreads down the head to the eyes and makes the fish blind. It subsequently appears on different parts of the body and on the extremities of the fins and tail. The fish diseased were beginning to die, which indicates that they will not last more than a week or ten days after they become affected.

An examination of the pond revealed no reason for any unhealthful conditions. Neither did there seem to be anything through which the water was flowing before it reached the pond to cause it to be unhealthful. Some fish that were in the towing pontoons which had recently been taken from the fishermen's nets to be placed in the pond, were examined, and on a few of them the first stage of the disease above referred to was in evidence.

As it seemed possible that the scales might have been removed from the fish striking the top of the pontoons, one of the fishermen's nets was visited and when lifted there were three salmon and a grilse in it. Two of the salmon were large females weighing about fifteen pounds, and they were perfectly healthy, but the third, a small male weighing 5 or 6 pounds, was apparently affected, as the scales were eaten away from the back of the head and he had an unhealthy appearance.

It would appear from the above that an epidemic has broken out amongst the fish in the river, and in view of the importance of the matter it is desirable that a capable bacteriologist should be immediately sent to the pond to thoroughly investigate the whole matter. I may add that this pond has been in operation for many years and in no instance in the past has any such trouble been experienced. The tide enters the pond, and at each high tide the water is slightly brackish.

I shall be obliged if you will give the matter immediate consideration and wire me whether the Biological Board can at once arrange to send a properly qualified man to investigate the matter. If it cannot, it may be possible for the Department to arrange with that of Agriculture to send an officer from the laboratory at the Experimental Farm here.

N.B.—Since writing the above a report has just been received from the officer in charge of the Port Arthur hatchery, in which he states that a disease, apparently of a similar nature, has broken out amongst salmon trout in the Nipigon river. This is the first time that the department has heard of any such disease there.

A few days later I received a statement from Dr. Huntsman, the main points of which are contained in his report on this outbreak of salmon disease, now being published.

On the arrival of the specimens of fish sent by Dr. Huntsman, they were immediately examined. They arrived in good condition, packed in ice, and were opened in the usual way. After examination of the organs and the flesh near the abraded spots or where the fungus was growing, pieces of the various organs were excised with a sterile knife, and cut open with a second sterile knife, and a portion of the pulp, etc., of the organ removed by means of a sterile platinum loop. In a few cases pieces of the organs were taken out, seized with the forceps and scorched in the flame, and then cut open with a sterile knife and a portion removed to sterile petri dishes. In all cases the material was mixed with beef peptone salt-water agar, and from the various

fish a large number of colonies were isolated. These colonies were lettered and numbered, and besides those here described a large number of other colonies were isolated, which were compared and found similar to those mentioned by letter and number.

FISH No. 1. Appearance normal, with the exception of a few patches of diseased skin around the head. On opening, the organs appeared normal. Plates were made from milt, liver, swimming bladder, kidney, heart's blood. In all cases the material was transferred to sterile petri dishes and beef peptone salt water agar poured over. After the plates had set they were kept at 20°C. Results:—

Milt.—About 60 colonies.

Liver.—About 100 colonies.

Swimming bladder.—Contained a quantity of liquid. Very large number of colonies, too numerous to count.

Heart's blood.—About 300 colonies to the oese. All these colonies were very similar.

Kidneys.—About 90 colonies.

Four species were isolated from this fish, marked A1, A2, A3, A4.

Flesh near diseased skin normal in appearance.

FISH No. 2.—External appearance normal except some bruises with traces of the fungus development near tail and head. On opening, the liver was rather pale in colour, somewhat friable, intestines empty, caeca empty. Right ovary eggs pink in colour; left ovary eggs much darker in colour, almost liver-coloured. Flesh normal and good colour. Same technique. One oese from each of the parts mentioned.

Ovary.—Pink eggs. From one crushed egg 300 or 400 colonies developed. A larger number from the one crushed egg from the dark red left ovary.

Liver.—20 colonies.

Heart's blood.—60 colonies per oese, all practically identical.

Isolations B1, B2, B3, B4.

FISH No. 3.—Exterior appearance normal with the exception of a few small areas discoloured visible in the skin. Flesh normal in appearance. Interior organs apparently normal. Smears from the various organs showed bacteria.

Heart's blood.—About 250 colonies to the oese, all similar.

Eggs.—Innumerable colonies. Two species.

Liver.—20—30 colonies per oese.

Kidneys.—80—100 colonies.

Two isolations—C1, C2.

FISH No. 4.—A large fish; much gelatinous slime around the tail. Some areas of skin affected with the fungus. Flesh beneath appeared healthy. Intestines slightly congested, empty. Liver dark in colour. Eggs salmon pink in colour, apparently normal. Swimming bladder empty. Smears from the heart's blood liver and kidney showed a number of organisms:—

Heart's blood.—30—40 colonies, all similar.

Liver.—10—12, all similar.

Kidneys.—20 colonies, all similar.

Eggs.—About 150 per egg. This is an estimate, as a large growth had occurred in the vicinity of the crushed part of the egg.

One isolation, D1.

FISH NO. 5.—Skin between the eyes and the back of the head was bruised and in places dirty white in colour. Microscopical preparations showed the presence of fungus. Flesh normal. All organs normal. Intestines empty. Smears from the milt, liver, heart's blood showed a number of organisms. Plates:—

Heart's blood.—Numerous colonies.

Liver.—40—50 colonies.

Milt.—A few colonies.

Three isolations—E1, E2, E3.

FISH NO. 6.—Skin bruised between eyes, fungus present in this area. Flesh normal. Organs normal in appearance. Intestines empty. Eggs, salmon pink in colour. Intestines slightly congested. Smears from heart's blood, liver and egg showed bacteria present. Plates:—

Heart's blood.—About 80 colonies, all similar.

Liver.—30—40 colonies, all similar.

Eggs.—One egg about 200 colonies, all similar.

One isolation, F1.

FISH NO. 7.—A large amount of diseased skin from which preparations of the fungus were prepared. Flesh normal. Intestines empty. Organs apparently healthy.

Kidneys.—About 30 colonies, all similar.

Liver.—About 50 colonies, all similar.

Heart's blood.—30—40 colonies, all similar.

One isolation, G1.

FISH NO. 8.—Large amount of diseased skin from which fungus growth was easily demonstrated. Liver pale in colour. Ovary deep reddish. Intestines empty. Many whitish eggs in ovary. Spleen normal. Plates:—

Egg.—About 150 colonies to the egg, large masses of bacterial growth near the crushed portion.

Liver.—About 250 colonies.

Heart's blood.—About 150 colonies, all similar.

A number of diseased portions of skin were cut off and examined in a variety of ways. Very good prepartions were obtained by teasing portions of the diseased skin, triturating the material with 40 per cent potassium hydrate. After removal from this reagent they were washed in water and transferred to Lugol solution, or else stained with safranin, eosin, or fluorescein, dehydrated and mounted in balsam. Such teased particles of the skin gave, as a rule, better results than sections.

These preparations show that the fungus was a *Saprolegnia*, and I presume that full particulars of this fungus have been already given by Dr. Huntsman. A very full account of the salmon disease probably caused by *Saprolegnia* is given in the report of the United States Commissioner of Fisheries for 1878, the article having been reproduced from the proceedings of the Royal Society of Edinburgh, written by A. B. Stirling, of the Anatomical Museum of the University of Dublin. A very comprehensive paper by S. Walpole and Prof. T. H. Huxley entitled "Disease among the Salmon of many Rivers in England and Wales" appears in the bulletin of the United States Fish Commission, vol. 1, 1881, and was a reprint of a pamphlet contained in the "21st Annual Report of the Inspector of Fisheries for England and Wales for the year 1881 presented to both Houses of Parliament by command of Her Majesty."

It seemed peculiar that injuries, which appeared at first to be mere abrasions, and which subsequently became infected by the fungus *Saprolegnia*, should have such

a disastrous effect upon the fish as to produce sluggishness and death in the short period of time mentioned by the officer of the hatchery and by Dr. Huntsman, and it therefore seemed important to make a thorough examination of the diseased fish to see if there were other factors producing disease, and to ascertain if the fungus *Saprolegnia,* was a primary or a secondary invader. Unfortunately such investigation was hampered by the fact that no live salmon were available for inoculation, and the only means of ascertaining the pathogenicity of the organisms isolated was to attempt to infect the common gold fish.

During the course of this examination I obtained a publication of the Fishery Board of Scotland entitled "The Life-history of Salmon in Fresh water, Glasgow, 1898," containing a paper by J. Hume Patterson, Assistant Bacteriologist of the Corporation of Glasgow, on "The Cause of Salmon Diseases", and I am indebted to this paper for the methods which were subsequently used for the inoculation of the live gold fish.

Before the gold fish could be inoculated it was necessary to work out in some detail the various organisms which were isolated from the salmon. The principal biological and cultural characteristics of those were as follows:—

A. 1.

A medium sized bacillus with rounded ends, occasionally bent, which occurs singly and sometimes in short chains. Actively motile, stains well with methylene blue, and is gram negative.

Gelatine Plates:—

24 hours, colonies just visible to the naked eye.

48 hours, colonies 2 mm. in diameter, round, with a liquefying centre saucer-shaped. Centre of the colony dense with a mass of deposited bacteria.

With ⅔ objective edges of the colony seemed slightly fimbriate, and the mass within the centre might be seen moving.

3 days, colonies had grown to between 5 and 9 mm. in diameter, but with similar appearance to that at 48 hours.

4 days, geletine completely liquefied.

Gelatine Stick:—

Growth is best at the top. Line of puncture filiform.

24 hours, Liquefaction begins, extending to the sides of tube and about 2 mm. in depth.

48 hours, growth uniform, line of puncture a cloudy area 10 mm. in diameter with small outgrowths into gelatine forming a cloudy cylinder. At the surface liquefaction is stratiform to a depth of 4 mm.

3 days, the growth has increased, stratified liquefaction extended to a depth of 7 mm. and the cloudy area looks like a saccate cylinder.

8 days, liquefaction to a depth of 8 mm.

10 days, there is a distinct dark stratum underneath the liquefied area.

13 days, very slight increase.

Beef Peptone Agar, 48 hours:—

Colonies 1 - 2 mm. diameter, round, raised, entire edge, glistening white appearance. With the ⅔ objective the edges were entire, colonies dense, and grandular with a narrow clear margin.

3 days, colonies 2 - 5 mm. diameter, round, more massive and dense, convex, whiteish to light brown in centre.

Sloped Beef Peptone Agar, Blood Heat (37·5):—

Little change after three days' growth.

The organism grew fairly well at blood heat.

24 hours, spread over about half the sloped surface.

48 hours, growth denser, spreading, flat, glistening, smooth, semi-opaque, whiteish. No further change.

Glucose Agar Slope:—

24 hours, at room temperature, smooth, vigorous, whitish, moist and spreading. Cloudiness near the growth.

5 days, colony more cloudy, considerable gas production and the column of agar is burst apart in the middle.

Glucose Agar Stick:—24 hours. Growth vigorous over surface and pronounced cloudiness from the surface to a depth of 10 mm.

48 hours. Increase in growth and a few gas bubbles appear on the line of puncture.

No further change occurs.

Beef Broth:—

24 hours, strong, cloudy.

3 days, much heavier. Sediment flocculent.

7 days, yellowish-green appearance in the upper layer otherwise no change.

Dunhams's Solution:—

The organism grew well in Dunham's solution, and at the end of 5 days at room temperature was tested with Ehrlich test, allowed to stand 20 minutes and the results then recorded. This organism was negative to this test. No Indol.

Milk:—

24 hours, no change.

3 days, coagulated with extrusion of slight amount of whey.

5 days, curd has become firmer, and a cheesy smell developed.

7 days, slightly more whey extruded;

No other change, although observed for some twenty days.

Litmus Milk:—

24 hours, no change.

48 hours, no change in constituency, but colour is changed to avellaneous.[1]

5 days. Colour uniform, slight digestion with separated whey, soft curd, yellowish ring around glass, smell disagreeable.

3 weeks.—Curd still undigested, whey yellowish, yellow ring, curd avellaneus, few gas bubbles on shaking.

Potato:—

24 hours. Moderate, dry, slightly raised, cream-coloured growth.

48 hours Increase of growth, dry, raised, slightly rugose, cream-yellow colour.

6 days. Abundantly raised, massive, rugose growth, cream colour at margins and pinkish on top. Odour unpleasant and slightly pungent, resembling that on milk.

3 weeks. No change.

A. 2.

Small bacillus with rounded ends, short, often in pairs, actively motile, stains well with methylene blue, and is gram negative.

[1] *Chromotaxia seu Nomenclator Colorum.* P. A. Saccardo.

Gelatine Plates:—

24 hours. Colonies just visible to the naked eye.

48 hours. Colonies have attained a size of 2-3 mm. in diameter; round, saucer-shaped. In the centre a dense mass of deposited bacteria with liquefying area around. With ⅔ objective interior of the colony is glumose. Edges clearer, but less distinct than A. 1.

3 days. In moderately seeded plates there is complete liquefaction.

Gelatine Stick:—

24 hours. Growth uniform. Line of punctures a cloudy area 5 mm. in diameter along line. Liquefaction begins in 24 hours, extending to sides of tube and 3 mm. in depth.

48 hours Increase in growth with similar appearance, and stratified liquefaction to a depth of 5 mm. Liquefaction gradually increases.

4 days. 10 mm. deep and the remainder of the tube saccate liquefies.

6 days. Liquefaction to a depth of 4 cm.

10 days. Liquefaction of the gelatine in the tube complete.

Beef Peptone Agar:—

48 hours at room temperature. Colonies 1-2 mm. in diameter, raised, glistening, whitish colony by reflected and greenish opalescent by transmitted light. With ⅔ objective edges entire, centre granular with a clear hyaline margin all around.

3 days. Not much increase in size, but more in density. Colony becoming whiter and more convex, somewhat resembling a yeast colony.

Beef Peptone Agar, at 37°C.:—

Very slight growth at *24 hours,* after which there was no further growth.

Glucose Agar Slope:—

24 hours. Abundant, flat, slightly spreading, smooth, moist, whitish growth.

No further change noticed until about second week, when the agar becomes brownish beneath the slope.

Glucose Agar Stick:—

24 hours. Growth filiform on surface, thin and spreading. Not characteristic.

48 hours. Gas bubble on surface and below. Afterwards no further change.

Beef Broth:—

24 hours, strong clouding, which increases, with abundant sediment.

No further change.

Dunham's Solution:—

5 days, at room temperature; tested with Ehrlich's reagents; allowed to stand for 20 minutes and then recorded. No Indol.

Milk:—

24 hours. No change.

3 days. Coagulated with extrusion of slight amount of whey.

5 days. Curd becomes firmer, and cheesy smell develops.

Amount of whey increases up to seventh day, after which there is no further change.

Litmus Milk:—

24 hours. No change.

48 hours. No change in colour or consistency; on shaking numerous small gas bubbles appear and form a foam on surface.

6 days. Coagulated, moderately firm curd, liliacinus in colour. About a quarter of the tube is whey, and much darker in colour (atro-violaceus).

3 weeks. There is a reddish ring at the surface, considerable digestion, whey occupying three-quarters of the tube, isabellinus in colour. Curd flocculent, avellaneus; odour slightly cheesy.

Potato:—

24 hours. Growth moderate, filiform, slightly raised, cream-yellow colour. This increases, and in

6 days growth is moderate, raised, rugose, moist, shiny; dirty cream-yellow, darker in centre where growth is most massive.

3 weeks. No further change.

A. 3.

Medium-size bacillus with rounded ends, resembles A. 1 in appearance. Active motile, stains well with methylene blue, and is gram negative.

Gelatine Plates:—

24 hours. Just visible to the naked eye. Growth rapid.

48 hours. Colonies are 2-5 mm. in diameter, round. Liquefaction saucer-shaped, inner ring dense, caused by deposited bacilli. With ⅔ objective the edges of the colonies are fimbriate centre grumose and flocculent. Masses of the bacteria can be seen in movement.

3 days. Colonies increase to 12 mm. in diameter, saucer-shaped liquefaction, whitish in centre, more transparent at the margin. To the naked eye the edges are entire, but with a microscope slightly fimbriate. There is a cheesy smell on opening the plates.

4 days. Plates are liquefied.

Gelatine Stick:—

24 hours. Resembles A. 1, but slightly less growth.

48 hours. Line of bacteria is filiform, smooth on surface. Liquefaction stratiform, 4 mm. deep. Liquefaction continues.

10 days. Liquefaction is 1 cm. deep with medium beneath darker in colour, but clear.

Agar Plates:—

48 hours. Colonies are 1-3 mm. in diameter, round, raised, yellowish-white. With ⅔ objective edges are entire, dark in centre, granular, gradually becoming lighter to margin, which is clear.

3 days. Colonies are round, white, edges entire, brownish in centre. Convex.

4 days. No change.

Agar Slope, 37°C.:—

24 hours. Very slight growth, filiform.

7 days. No further change.

Glucose Agar Slope, 20°:—

A spreading, flat, white, shiny growth; agar beneath very cloudy. Cream yellow. No gas.

Glucose Agar Stick:—

Growth filiform, spreading; cream colour at centre, lighter at margins. Cloudy to half-way down the agar.

Beef Broth:—

24 hours. Clouding moderate. Sediment.
3 days. Growth heavier, slight pellicle.
5 days. Ring and pellicle.
7 days. Yellowish-green colour in upper layers.
Subsequently no change.

Dunham's Solution:—

Grown for five days at room temperature, tested with Ehrlich test, allowed to stand 20 minutes and then recorded. No Indol.

Milk:—

Fifth day. No change until the fifth day, when there is coagulation with soft curd, cheesy odor. Curd gradually becomes harder and the whey greenish in colour. Digestion takes place to about half the volume.

Litmus Milk:—

The colour is gradually bleached and in *48 hours* is avellaneus.
5 days. Coagulation takes place in 5 or 6 days, a soft, fine curd which gradually digests. Blue ring at the top; separated whey is isabellinus in colour.
3 weeks. Greenish-blue colour; whey thick, curd avellaneus, odour unpleasant.

Potato:—

24 hours. Growth moderate, raised, filiform, cream-yellow in colour.
48 hours. Growth becomes dirty and ochraceus, slightly rugose. Growth gradually changes to ferrugineus in colour.
3 weeks. No change.

A. 4.

A small bacillus, short, rather stout, with rounded ends. In appearance resembles A. 2. Actively motile, stains well with methylene blue, and is gram negative.

Gelatine Plates:—

24 hours. Just visible to the naked eye.
48 hours. Colonies punctiform (less than 1 mm.) white and glistening, with $\frac{2}{3}$ objective they are seen to be round, with entire edges, and granular.
3 days. Colonies slightly punctiform, white, glistening, convex, capitate. With $\frac{2}{3}$ objective edges entire and granular.
No further change.

Gelatine Stick:—

24 hours. Growth unifrom, line of bacteria filiform.
48 hours. Growth filiform to villous. Four gas bubbles on line of bacteria.
3 days. There is more growth. Line of bacteria villous to papillate.
10 days. Slight depression at the point of puncture may be noticed, but no liquefaction.
13 days. Liquified area around the line of puncture.

Agar Plates:—

48 hours. Colonies are filiform, glistening, raised. With ⅙ objective the colonies are round, dense in centre, and granular, clearer at margin, edges entire.

3 days. Colonies slightly larger, opalescent, white.

No further change.

Gelatine Agar Slope at 37° C:—

Little, if any, growth observed. Continuous observation for 7 days.

Glucose Agar Slope:—

Growth moderate, moist, shiny, slightly raised, whitish.

3 weeks. Agar is brown beneath the slope.

Glucose Agar Stick:—

Growth filiform, thin surface, growth spreading. Gas bubbles along line of puncture.

No further change except the agar becomes brown beneath the surface to a depth of 1–2 cm.

Beef Broth:—

24 hours. Slight clouding and sediment.

3 days. Clouding and sediment increase slightly.

No further change.

Dunham's Solution:

Grown for five days at room temperature, tested with Ehrlich test, allowed to stand 20 minutes and then recorded. Indol positive.

Milk:—

5 days. No change visible.

6 7 days. On shaking tube a gassy foam rises to the surface.

10 days. Milk had coagulated, hard curd, whitish whey.

Litmus Milk:—

No change in appearance in *24 hours.*

48 hours. Abundant gas which rises to the surface in small bubbles. This was noticed each day up to the sixth day, and the foam was very heavy. The milk gradually coagulates and forms a blue ring down one side of the tube, remainder is a firm curd adhering to the tube. Bleached cream colour.

Potato:—

24 hours. Moderate growth, filiform, slightly moist, cream coloured.

48 hours. Becomes slightly rugose.

6 days. Growth slight, slightly raised, and a dirty yellow (melleus).

3 weeks. No further change.

B. 1.

This organism on examination was found to resemble in all respects A. 1.

B. 2.

A small size bacillus about 1½ times as long as wide, rounded end, frequently in pairs. Actively motile, stains well with methylene blue, negative with gram.

Gelatine Plates:—

24 hours. Visible to the naked eye.
48 hours. Punctiform, colony raised, glistening, whitish. $\frac{2}{3}$ objective shows round, dense, granular colony, entire edges.
No further change.

Gelatine Stick:—

24 hours. Growth uniform, round, filiform; no liquefaction.
48 hours. Growth uniform, no liquefaction to surface.
3 days. Slight depression at the boint of bacteria. No liquefaction.

Agar plates:—

48 hours. Uniform, 1 m.m. in diameter, round, glistening, colony. With $\frac{2}{3}$ objective round, dense, shading to lighter; granular, edges entire.
3 days. Colonies are glistening and bluish white.
No further change.

Agar slope 37° C.:—

7 days. Very slight growth, one or two small colonies appearing on the surface but otherwise no change.

Glucose Agar Slope:—

Moderate growth, spreading, flat, moist and whitish.
48 hours. A few gas bubbles appear and slight increase in growth.
3 weeks. Agar is brown underneath the slope.

Glucose Agar Stick:—

Filiform, slight growth on surface, gas bubbles along line of puncture.
No further change except for browning of the agar underneath the surface.

Beef broth:—

24 hours. Moderate growth, moderate sediment.
3 days. Growth slightly heavier.
5 days. Clearing.
No further change.

Dunham's Solution:—

Grown for five days at room temperature, tested with Ehrlich test, allowed to stand 20 minutes and then recorded. Indol positive.

Litmus Milk:—

24 hours. No change.
48 hours. A fine foam on the surface when tube is shaken. Colour liliaceous, no coagulation.
6 days. Much gas in foam form. No coagulation. Colour liliaceous. Colour gradually bleaches. Blue ring forms on surface. Bluish whey but little digestion.

Potato:—

24 hours. Filliform, dry, raised, colour niveus.
6 days. Growth becomes slightly raised and more massive.
3 weeks. No change.

B. 3

Resembles in all respects *A. 4*.

B. 4.

Resembles in all respects *A. 4.*

C. 1.

Small to medium bacillus about twice as long as broad, slightly rounded ends. Actively motile, stains somewhat unevenly with methylene blue, gram negative.

Gelatine Plates:—

24 hours. Colonies visible to the naked eye.

48 hours. Colonies punctiform, round, white, raised and glistening. ⅔ objective round, evenly dense and granular with entire edges.

No further change.

Gelatine Stick:—

Growth uniform, line of puncture filiform, 4 gas bubbles along line of puncture.

10 days. Depression at the point of puncture.

13 days. Line of bacteria has liquefied.

Agar Plates:—

48 hours. Colonies are punctiform, 1-1½ mm. in diameter, round, raised, white, glistening.

With ⅔ objective colonies are round, dense in centre, clear margins, granular, entire edges.

No further change.

Agar, 37°C.:—

24 hours. Moderate growth, flat, slightly spreading, smooth and translucent.

No further change.

Glucose Agar Slope:—

Flat, moist, spreading, whitish growth, few gas bubbles.

No further change except browning of the agar beneath surface.

Glucose Agar Stick:—

24 hours. Filiform, growth spreading on surface.

48 hours. Few gas bubbles along line of puncture.

No further change.

Beef Broth:—

24 hours. Moderate clouding, flocculent, abundant sediment.

5 days. Clearing.

No further change.

Dunham's Solution:—

Grown for five days at room temperature, tested with Ehrlich test, allowed to stand 20 minutes and then recorded. Indol positive.

Litmus Milk:—

24 hours. No change.

48 hours. Slight amount of gas, colour somewhat lighter, no coagulation.

6 days. Much gas in foam form. No. coagulation. Colour liliaceous.

Subsequently milk coagulates, blue ring, surface clear, whey on one side, curd adhering to two-thirds of the tube; bleached to a cream colour and of firm consistency.

Potato:—

Slightly raised, moderate growth, cream-yellow.
3 weeks. No further change.

D. 1.

Medium-size bacillus, with slightly rounded ends, actively motile, stains well with methylene blue, gram negative.

Gelatine Plates:—

Colonies visible to the naked eye in *24 hours.*
48 hours. Uniform, round, white, glistening colony; $\frac{2}{3}$ objective round, granular, dense to the edge, edges entire.
3 days. Colonies become more dense. Convex.
No further change.

Gelatine Stick:—

48 hours. Line of puncture is villous. Slight softening of the gelatine on the surface.
Subsequently growth along line of puncture becomes villous to papillate, softening gradually extending along line of puncture.

Agar Plates:—

48 hours. Punctiform to 1 mm. in diameter, round, white, raised, glistening colony; $\frac{2}{3}$ objective colonies round, dense in centre to clear margin, granular, edges entire.
3 days. Slight increase in sizes; otherwise no change.

Agar slope, 37° C.:—

No growth at this temperature.

Glucose Agar Slope:—

Moist, flat, spreading, whitish growth. Agar becomes brown beneath the growth, but no further change.

Glucose Agar Stick:—

Line of puncture filiform, spreading on surface, three or four small bubbles appear in *48 hours* and slight increase in growth; otherwise no change except browning under growth.

Beef Broth:—

24 hours. Growth moderate, sediment moderate and flocculent.
5 days. Clearing.
No further change.

Dunham's Solution:—

Grown for five days at room temperature, tested with Ehrlich test, allowed to stand 20 minutes and then recorded. Indol positive.

Litmus Milk:—

24 hours. No apparent change, but on tapping the tube small gas bubbles rise to the surface.
48 hours. Gas more pronounced. Colour liliaceous.
6 days. Foamy gas. No coagulum. Colour liliaceous.
3 weeks. Blue ring on surface cleared away along one side, remainder firm curd adhering to the tube. Bleached cream colour.

Potato:—

Moderate growth, raised, rugose, waxy, cream yellow in colour.

E. 1., E. 2. and E. 3.

Resemble *A. 1.*

F. 1.

Medium size bacillus with rounded ends. Actively motile.

On staining with methylene blue there are two or three dark granules in most of the organisms. Gram negative.

Gelatine plates:—

24 hours. Just visible to the naked eye. Round, white, glistening, $\frac{2}{3}$ objective brown, edges entire, granular.

Subsequent liquefaction.

Gelatine Stick:—

Growth uniform, line of puncture filiform, growth becomes slightly heavier and on the 6th day there is a slight liquefied depression.

10 days. Liquefaction is infundibuliform.

13 days. Complete liquefaction.

Agar Plates:—

Agar slope, 37°:—

Very slight, if any, growth (7 days).

Glucose agar slope:—

Filiform, non-spreading growth.

Glucose Stick:—

Filiform growth, nothing on the surface.

6 days. Slightly heavier, subsequently no change.

Beef Broth:—

Slight clouding, flocculent sediment.

3 days, clearing.

No further change.

Dunham's Solution:—

Grown for five days at room temperature, tested with Ehrlich test, allowed to stand 20 minutes, and then recorded. Very weak Indol.

Litmus Milk:—

6 days. No change visible until 6th day, when colour becomes darker. This increases.

6 weeks. Colour is atrocyaneus. There is progressive digestion without coagulation.

Potato:—

Whitish growth restricted and filiform.

3 weeks. No further change.

G. I.

Medium size moderately thick bacillus with rounded ends, very considerable variation as to size, actively motile, stains well with methylene blue, gram negative.

Gelatine plates:—

24 hours. Just visible to the naked eye.

48 hours. Punctiform.

8 days. 1 - 5 mm. in diameter, round, saucer-shaped, liquefaction. Whitish in colour, most dense near centre. Radiating lines like the spokes of a wheel from the centre consisting of deposited bacteria. With $\frac{2}{3}$ objective edges are entire and interior granular to grumose.

4 days. Plates have liquefied.

Gelatine Stick:—

48 hours. Liquefaction heavier, 6 mm. in depth. This increases and is strati-form to sacchate. In ten days tube is completely liquefied.

Agar Plates:—

Agar slope, 37°:—

Very slight growth, in 24 hours.

48 hours. More abundant growth, spreading, flat, glistening, semi-opaque.

3 days. Slightly heavier.

No further change.

Glucose agar slope:—

Moist, white, spreading, smooth, Gas in condensation water.

3 weeks. Cream-yellow colour at the base of the slope, and centre of surface growth.

Glucose Stick:—

Filiform, slightly spreading on surface, 3 or 4 gas bubble along line of puncture.

No further change.

Beef Broth:

24 hours. Strong, cloudy, moderate sediment.

3 days. Pellicle over entire surface.

7 days. Yellow-cream colour in the outer layers.

No other change.

Dunham's Solution:—

Grown for five days at room temperature, tested with Ehrlish test, allowed to stand 20 minutes, and then recorded. Indol very strong production.

Litmus Milk:—

48 hours. Colour is lighter.

2 days. Alkaline digestion commences.

6 days. Almost complete digestion, remaining curd, in fine particles, dirty violaceous in colour. Whey $\frac{3}{4}$ of tube. Semi-transparent and avellaneous in colour, no odour. Blue ring at surface.

Potato:—

24 hours. No apparent change.

48 hours. Slight growth, filiform, yellowish.

6 days. Moderate growth, slightly raised, moist on the moist part of potato and dry at the top, ferruginious in colour.

3 weeks. Colour is redder, otherwise no further change.

H. I.

A short to medium stout bacillus, actively motile, stains well with methylene blue, is gram negative.

Gelatine Plates:—

24 hours. Just visible to the naked eye.
4 days. Punctiform, later liquified.

Gelatine Stick:

Growth uniform, filiform.
48 hours. Slightly liquefying, 2 mm. in depth, stratiform. Liquefaction increases and is slightly sacchate with flocculence.
10 days. Liquefaction becomes infundibuliform.
15 days. Whole tube is liquefied.

Agar Plate:—

48 hours. Round, uniform, glistening, colony. With $\frac{2}{3}$ objective round, edges slightly erose. Slightly granular colony.
3 days. Colony becomes more massive and bluish white; otherwise no further change.

Agar Slope, 37°:—

Very slight growth, one or two colonies. Increases along line of puncture.
7 days. No further change.

Glucose Agar Slope:—

Thin, translucent, moist, film in 24 hours. No further change.

Glucose Stick:—

Filiform. No surface growth.

Beef Broth:—

24 hours. Slight clouding, flocculent and abundant sediment.
3 days. Clearing.
7 days. No further change.

Dunham's Solution:—

Grown for five days at room temperature, tested with Ehrlish test, allowed to stand 20 minutes, and then recorded. Indol very strong.

Litmus Milk:—

24 hours. No change.
48 hours. Tubes become darker in colour, atro-violaceous. No coagulation. Subsequently there is gradual digestion. Whey first with a violet shade, throughout, which gradually concentrates as a deep blue ring on top, and curd becomes semi-transparent, isabellinus in colour, and thick but not viscous. A little undigested curd at bottom of tube. (3 weeks.)

Potato:—

24 hours. Very slight growth.
4 days. Growth moist, slightly raised, smooth. Colour brown, light testaceous.
3 weeks. Colour changes somewhat between rosaceous and testaceous. No further change.

SUMMARY OF CHARACTERS.

—	Diam. over 1 m.	Chains.	Spores.	Capsules.	Motile.	Gram.	Broth. Cloudy.	Broth. Ring.	Broth. Pellicle.	Broth. Sediment.	Agar. Shiny.	Agar. Dull.	Agar. Chrom.	Gel. Plate. Round.	Gel. Plate. Liquef.	Potato. Mod.	Potato. Colour.	Potato. Grows at 37 C	Milk. Acid curd.	Milk. Rennet curd.	Milk. Casein pep.	Milk. Gas.	Indol.	Gas in Gluc. Agar.
A 1.....	−	+	−	−	+	−	+	−	−	+	+	−	−	+	+	+	+	+	−	−	−	+	−	+
A 2.....	−	+	−	−	+	−	+	−	−	+	+	−	−	+	+	+	+	+	−		+	+	−	+
A 3.....	−	+	−	−	+	−	+	+	+	+	+	−	−	+	+	+	+	+	−	+	+	−	.	−
A 4.....	−	+	−	−	+	−	+	−	−	+	+	−	−	+	−	+	+	−	−	+	−	+	+	+
B 2.....	−	+	−	−	+	−	+	−	−	+	+	−	−	+	−	+	+	+	−	+	+	±	+	+
C 1.....	−	+	−	−	+	−	+	−	−	+	+	−	−	+	−	+	+	+	−	+	+	±	+	+
D 1.....	−	+	−	−	+	−	+	−	−	+	+	−	−	+	−	+	+	−	−	+	−	+	+	+
F 1	−	+	−	−	+	−	+	−	−	+	−	+	−	+	+	−	−	−	−	+	+	−	+	−
G 1.....	−	+	−	−	+	−	+	−	+	+	+	−	−	+	+	+	+	+	−	+	+	−	+	+
H 1	−	+	−	−	+	−	+	−	−	+	+	−	−	+	+	+	+	+	−	+	+	−	+	−
B Salmonis pestis.	?	+	−	−	+	−	+	−	+	+	+	−	−	+	+	+	+	−	+	−	+	−	.	−

CHARACTERISTICS OF THE MICRO-ORGANISM (*Bacillus salmonis pestis* Patterson).

Morphological Characters.

A short, thick bacillus with rounded ends, varying in length, occurring singly and in pairs lying end to end. Actively motile, non-spore-bearing, does not stain with Gram's method, grows rapidly and profusely at the room temperature, but shows little or no growth at 37° C., and is killed at this temperature in about six days.

The organism exposed to a mixture of ice and salt for a week not only survived that low temperature, but grew profusely while in the mixture. Involution forms were only observed in glucose media. It appears to be a strict aerobe. Pathogenic to fish, non-pathogenic to frogs, mice, and guinea-pigs.

Cultures.—Room Temperature.

Gelatine Plates.—In about three days small, greyish, pin-point colonies appear, with a ring of liquefaction around them of a transparent greyish colour, which rapidly increases, the plate becoming completely liquefied in about 36 hours after their appearance. The dense pin-point centre and transparent area of liquefaction around is markedly characteristic of the bacillus, together with the very rapid liquefaction of the gelatine.

Gelatine Stab.—Profuse growth along needle track at the end of 18 hours, which gradually increases and rapidly liquefies the gelatine.

Carbol Gelatine, 1 per cent Stab.—Slight growth in 18 hours along needle track, which gradually liquefies the gelatine.

Carbol Gelatine, ·05 per cent Stab.—The growth is more profuse.

Carbol Gelatine, ·03 per cent, Stab.—Very profuse growth.

Room Temperature.	37° C.
Agar Streak :—	
Dense, profuse, cream-coloured moist shining growth along needle track in 18 hours, with irregular margin, which gradually spreads over the surface of the agar.	Growth barely visible.
Agar Smear :	
Small pin-point cream-coloured colonies at the end of 18 hours with irregular spreading transparent margins.	" "
Agar Glucose Stab :—	
Profuse cream-coloured growth along needle track for about half an inch at the end of 24 hours, spreading on the surface. The agar gradually *becomes cloudy from the surface and parallel to it, and extends for about half an inch down the media. No gas production.*	" "
Agar Glucose Plate :—	
Cream-coloured colonies with moist shining surface and *white cloudiness around each Colony.*	" "
Blood Serum :—	
Bouillon :—	
At the end of 18 hours the bouillon becomes cloudy throughout, with a marked skim on the surface and clinging to sides of tube, with a slight deposit at the bottom.	No perceptible growth.
Bouillon (Glucose) :—	
Similar to ordinary bouillon, but growth much more profuse..	Very slight growth.
Bouillon Taurocholate Glucose :—	
Slight growth, turning the media slightly red. No gas formation...........	No growth.
Litmus Milk :—	
In about 48 hours there is a distinct acid reaction, which gradually increases, and in about seven days the milk becomes coagulated and gradually digested.	No perceptible change.
Peptone Water :—	
Marked cloudiness throughout at the end of 18 hours. Gives no indol reaction.	Very slight cloudiness at the end of 48 hours. Gives no indol reaction.
Potato :—	
Very profuse yellowish brown growth at the end of 18 hours, raised on the surface of media like blisters, with moist shining surface.	Very slight growth in 48 hours.
Agar (Anaerobically) :—	
No growth...	No growth.

The organism also withstands the effect of ordinary water, sterile water and *sea-water* for a considerable time, as flasks of those inoculated with it and kept at the room temperature for over a month gave profuse growths when reinoculated on agar. It does not, however, survive more than a week in distilled water. It also keeps well on sub-cultures, as tubes of agar inoculated from sub-cultures about a year old gave profuse growths in about 18 hours.

The chief characteristics of the bacillus are those :—

Actively motile, non-spore-bearing bacillus.
On sub-culture it grows profusely in 18 hours at the room temperature.
On sub-culture it grows profusely when exposed to 0 deg. C. for a week.
Shows *little or no growth at 37° C.*
Is *killed at 37° C.* (98·6° F.) in about six days.
Liquefies gelatine with extreme rapidity.
Coagulates and digests milk.
Forms a cloudiness in glucose agar in the neighbourhood of the growth.
Grows well in sea water.
Strict aerobe.
Involution forms only observed on glucose media.
Does *not* stain with Gram's method.
Pathogenic to fish.
Non-pathogenic to frogs, mice, and guinea-pigs.

CONCLUSIONS.

(1) The fungus *Saprolegnia ferax* is not the cause of the salmon disease.

(2) The disease is due to the invasion of the tissues of the fish by a special bacillus (*Bacillus salmonis pestis*).

(3) The bacillus gains access through abrasion or ulceration of the skin, and the disease is apparently not contracted when the skin of the fish is in a healthy state.

(4) *Bacillus salmonis pestis* can be transmitted from dead diseased fish to other dead fish in the same water.

(5) *Bacillus salmonis pestis* can be transmitted from dead fish to living fish in the same water, and since dead fish are a suitable nidus for the growth of the bacillus, it is obviously desirable to have all dead fish removed from the river immediately they are observed, and burned, as by simply burying, the germ is left in a condition to be again carried into the stream.

(6) The fact that the bacillus grows profusely when placed in a freezing mixture of ice and salt, while a temperature of 37°C. soon destroys it, shows that the cold season is more favourable to its growth.

(7) Fish akin to salmon are more susceptible to the disease than others, as rainbow trout, river trout, and sea trout when attacked succumbed in from two to four days, while dace and gold-fish died in about 18 and 35 days, respectively.

(8) *Bacillus salmonis pestis* grows well in sea water, whereas *Saprolegnia* does not grow at all; therefore a diseased salmon entering the sea, and returning to the river apparently free from fungus, cannot be said to be free from the disease.

GOLD-FISH EXPERIMENT.

Late in November a number of gold-fish were purchased and placed in a large tank in one of our laboratories. The change of water resulted in a few dying, so to avoid any errors due to management we kept them for a month before inoculation. They were then removed from the aquarium and two fish were placed in each of eight large museum jars, and kept thus for another week. The water was changed every third day, and the fish fed every alternate day.

The inoculation was carried out in the following manner: The fish was taken out with the hand and the top of the head and part of one side near the gills gently rubbed with sandpaper until there was a slight effusion of blood, and this abraded area was then rubbed with a platinum oese of 3 mm. charged with material taken from a 24-hour-old agar slope culture. A separate piece of sandpaper was used for each fish. Several loopsful of the culture were added to the water of each jar.

In this way organisms A1, A2, A3, A4, B1, B2, C1, D1, E1, F1, G1 were inoculated in duplicate, and four fish were rubbed with sandpaper but not inoculated. The fish were observed daily, and the inoculated water was changed on the third day.

The control fish rubbed with sandpaper and not inoculated are still alive, and of the inoculated fish, one in each of the jars inoculated with A, A2, B2, C1, and D1, died 22, 30, 34, 27, 43 days ofter inoculation.

Bacteriological examination was made of these fish, but in no case was I able to obtain from the dead fish the organism which was inoculated. Evidently these organisms were non-pathogenic to gold-fish. One fish in each of the jars from which the dead fish were taken remains alive, and, at the time of writing (May 10) appear quite normal. Of course there is the possibility that some of the organisms isolated might be pathogenic for salmon and not for gold-fish.

Patterson states with reference to his *B. salmonis pestis* that:—

> "Dace inoculated with this bacillus died as the result of inoculation in from two to seven days. Dace, river trout,. sea trout and gold fish inoculated

with *Saprolegnia* remained healthy. Dace, sea trout and one gold fish inoculated with *Saprolegnia* and *B. salmonis pestis* died in various periods of time (2 to 18 days) except the gold fish which died after inoculation and showed signs of the fungus on the gill covers. No attempt was made to make cultures from the dead gold fish."

Patterson concludes that:—

"*Saprolegnia* grows on live fish in the presence of the organism, which breaks down the superficial tissues and forms a suitable nidus for the fungus to grow on."

I had no *Saprolegnia* to try similar experiments.

The difficulty of obtaining and keeping fish for experiments in a laboratory unequipped for such work, and the difficulty because of lack of laboratory equipment to carry out experimental work at the hatchery, will have to be overcome before any decisive experiments can be undertaken.

It is, however, significant that all organs apparently healthy in the salmon examined contained bacteria in large numbers, and of comparatively few species, and I am unable to state or find in any literature or obtain information as to the bacterial content of the normal organs of fish, or how soon after death, and to what extent, these organs are invaded by bacteria. Very large numbers of bacteria were found in the eggs from a number of the fungus-infected salmon, and under normal conditions one would scarcely expect to find so many bacteria present.

All that can be stated at present is that Patterson's organism, *B. salmonis pestis*, was not found, and that the large number of bacteria present accompanying the *Saprolegnia* may have some pathogenic role, but the rules of proof (Koch's postulates) would have to be worked out where fish, the means of keeping them, and laboratory facilities are provided.

IX

REPORT ON AFFECTED SALMON IN THE MIRAMICHI RIVER, NEW BRUNSWICK.

(By A. G. Huntsman, B.A., M.B., F.R.S.C., etc., Curator of the Biological Station, St. Andrew's, New Brunswick.)

In the early part of October, 1915, Mr. G. J. Desbarats, the Deputy Minister of the Naval Service, requested that the Biological Board arrange an investigation of a disease which had broken out among the salmon in the Northwest Miramichi river. I was instructed to proceed to the Miramichi hatchery, South Esk, New Brunswick, examine the conditions there, investigate the possibility of organisms other than bacteria being responsible for the disease, and arrange for the shipment of material for bacteriological examination to Principal F. C. Harrison, of Macdonald College, Ste. Anne de Bellevue, Que.

The hatchery was visited on October 11 and 12. It is located near the mouth of a small stream which empties into the Northwest branch of the Miramichi river, a few miles from Newcastle. Mr. Donald Morrison, the local inspector of fisheries, and Mr. Wm. Sheasgreen, the officer in charge of the hatchery, gave every assistance.

Down the stream from the hatchery is a pond for retaining the salmon previous to the stripping at spawning time. It consists of a portion of the stream enclosed by boards, with spaces between for the circulation of the water. The water is changed regularly by the action of the tide and by the current of the stream. The level of the water in the pond is prevented from falling too low by a dam across the stream below the pond.

A large proportion of the fish in the pond had been officially reported to be visibly affected, and I found white patches of fungus with extensive ulcerations in the centre of many of the patches in the worst cases. The head, the back, and the tail were the parts that in most instances showed evidence of the disease. In the earlier stages the affected parts were seen to be covered with a greyish thin film of fungus, which was easily rubbed off. If the fish were removed from the water these greyish patches could scarcely be seen. The fish that were in the worst condition were sluggish, came inshore into the shallow water, or floated near the surface with the fins exposed. Frequently the caudal fin was partly out of the water and the head very low, the fish floating at an angle approaching the vertical.

Mr. Sheasgreen gave the following information on October 12:—

> "During the latter part of September small marks, chiefly on the head, were noticed on a large proportion of the fish in the pond. A few marked fish (those with definite wounds) had been received from the fishermen. It has been the custom whenever an opportunity presented to take these marked fish from the pond and bury them. The records show that twenty-two fish were taken out from the 18th to the 21st of September, three on the 25th, and five on the 28th. On the outbreak of the disease (the last of September) at first only dead fish were removed, but later badly infected living ones as well. Beginning with September 30, fish were received every day, never less than seven, and once as many as thirty-eight. The dead fish were all well covered with the fungus. On October 6 we began to reject some of the fish brought in by the fishermen, who by this time were noticing the fungus on some of the fish that they were catching. Of the fish brought in there were no large number badly marked previous

to October 6. They all showed, if any, only slight marks, and no evident fungus. From that date on, from 15 to 30 per cent (2 to 4 out of every dozen) of the fish taken each day from three traps near the hatchery, of which records were kept, showed signs of the disease, and were rejected. The fish from a trap 2½ miles up the river showed twenty-six affected out of a total of fifty-two on October 6, twenty-two out of 40 on October 8, and three out of thirteen on October 11, apparently showing a steady improvement as if the infected fish had passed up the river. Up to nearly the 8th of October the salmon in the pond did not seem to be as active (jump as much) as in previous years, but since that date there has been a marked improvement.

"Last year (1914) there were 2,636 salmon in the pond. This year the pond has been enlarged and is from one-quarter to one-third larger than last year. The number of fish that had been placed in the pond previous to September 30 was 2,308.

"This disease has not been noticed in the salmon in any year previous to this, although salmon in the Gaspe region are reported to have had fungus disease last year."

From a comparison of the numbers of the fish and the sizes of the pond it is evident that there has been far less crowding of the fish this year than last. As to temperature, the Monthly Weather Reviews of the Meteorological Service show that at Chatham, 20 miles from the hatchery at the mouth of the Miramichi river, the mean monthly temperatures for the months of August and September, 1915, are only slightly (·6° and ·2°) above the averages for those months for the past forty years. And for the month of September both the mean temperature and the maximum temperature are lower than for the same month in 1914.

The temperature records for the water at the hatchery are incomplete. Temperatures were observed in the hatchery from August 30 to September 20. The records show a range from 50° to 68°F., with an average temperature of about 58°. Temperatures have been observed in the retaining pond from October 6 to 20, and show a range from 46° to 52°, the temperature remaining comparatively uniform during that period. Temperatures observed in the hatchery from October 14 to 20 show that on bright days the temperature in the pond is two to three degrees higher than in the hatchery, and on cloudy days about the same as in the hatchery. Judging from this, the temperature in the pond has at no time since fish were put in (September 11) been higher than 65°F. Temperature does not appear to have been a special causative factor in 1915. The gradual lowering of the temperature has doubtless helped to stop the spread of the disease, Mr. Sheasgreen stating that on October 20 no new diseased fish were appearing.

As to the place of origin of the disease, the presence of diseased fish among those caught in the traps over a considerable period of time indicates that the disease was present for some distance up and down the Northwest Miramichi river. Diseased fish were not noticed among those taken from the traps until one week after the disease had been observed in the pond. Mr. Sheasgreen states that he and his assistants buried all the fish removed from the pond. This obviates the possibility of fish from the pond having carried the infection to the fish in the river, although not the possibility of the pond having served as a source for the distribution of the infection up and down the river.

The avenue of infection appears to have been chiefly through abrasions of the skin. The principal parts seen to be affected in the early stages of the disease were: the tip of the snout, the margins of the jaws, the top of the head, and the middle line of the back, and the margins of the fins. These are the parts most liable to injury in the traps or in the cars used for transporting the salmon to the retaining pond. An examination of the fish caught in the traps and brought to the retaining pond on

October 12, all with no visible disease, showed that the great majority had some abrasions, the commonest being on the tip of the snout, the top of the head, and the margins of the fins (particularly the caudal). There were also net marks around the middle of the head and the marks of fish lice (removal of scales) along the middle line of the back in a number of cases. These marks explain the usual distribution of the fungus, the other parts of the body—for example, the sides—being attacked only in the later stages.

The vigour of the fish declines with the spread of the fungus. Fish with well-developed but localized patches of fungus on the head or elsewhere, or with wounds raw or bleeding, appeared to be nearly as vigourous as healthy fish. But if the fungus were present over much of the surface they were sluggish, came close inshore or floated near the surface with the fins, particularly the caudal, sticking out of the water. In the last stages they dropped to the bottom of the water on their sides.

The only data with reference to the rate of spread of the disease have to do with a fish put in clean on October 4th and removed on the 12th in a sluggish condition, with the fungus covering most of the surface, but so slightly developed that it was not easily seen after the fish had been removed from the water.

The salmon-louse [*Lepeophtheirus salmonis* (Kröyer), see Wilson, 1905, p. 640] was found on a fairly large proportion of the fish taken from the traps. It occurred chiefly along the middle of the back between the fins. It appears to be responsible for the removal fo the scales and doubtless determines the location of the disease in this region.

The fungus proved to be *Saprolegnia*, several species of which are commonly found growing on dead organic matter in fresh water. Prof. J. H. Faull of the University of Toronto, to whom material was submitted, informs me that it belongs to the *ferax* group of *Saprolegnia*, but since no oospores could be seen (they are rarely found) exact identification was impossible. Several species of the *ferax* group occur on dead or diseased fishes (Hofer, 1906, p. 106.) The growth and extension of the *Saprolegnia* proceeds *pari passu* with the disease and may be taken as an evidence of the extent of the disease. Whether its relation to the disease is to any extent a causal one or whether it is merely an accompaniment, may well be disputed.

An examination of the internal organs of the diseased salmon revealed no distinct lesions. A microscopic study of the body fluids and of sections of the organs likewise revealed nothing. We may conclude that the disease is confined strictly to the skin and subjacent parts.

The bacteriological examination of the diseased fish was in the hands of Principal Harrison. However, having some material, I handed over to Dr. H. K. Detweiler of the Pathological Department, University of Toronto, portions of the skin from fish in various stages of the disease. He very kindly had sections made and stained with thionin blue in order to demonstrate, if possible, the presence of the *Bacillus salmonis pestis*, which was found by J. Hume Patterson (1903) in cases of the salmon disease occuring in Great Britain. He informs me that no positive results have been obtained. Negative results in such a case prove nothing.

The gross characters of this disease appear to be identical with those of the well known salmon disease that appeared in the form of an epidemic among the salmon in certain rivers in the north of England and Scotland in 1877. It spread in the course of a few years to the neighbouring rivers up and down the coast and has continued in an endemic state in the waters of Great Britain ever since. No means of successfully combatting it has as yet been found.

The *Saprolegnia ferax* was for many years considered to be the cause of the disease (Stirling, 1878 and 1879, and Walpole and Huxley, 1882). In 1903, however, Patterson published the results of investigations which went to show that *Saprolegnia* was not

responsible for the disease, but a *Bacillus* (*B. salmonis pestis*). The *Bacillus* alone brought about the death of fish, but not the *Saprolegnia* alone. The latter was able to grow in tissues already invaded by the *Bacillus*. The *Bacillus* grew in sea water, but the *Saprolegnia* did not. Salmon affected by the disease while in salt water would therefore not show any fungus until after arriving in fresh water. Patterson states that the cold season is more favourable for the growth of the *Bacillus* and Malloch (1910, p. 117) states that the colder the weather the worse the disease becomes. But Patterson's experiments merely show that the *Bacillus* grows better at 0° C. (32° F.) than at 37° C. (98.6° F.), whereas at room temperature (60° F. ?) the growth was very much more rapid than at 0° C.

In the case of the disease in the Miramichi river, Mr. Sheasgreen has stated that the condition of the fish in the pond improved rapidly during the latter half of October and at the same time the number of diseased fish taken in the traps decreased. The lower temperature *may* have been responsible for this, either by improving the condition of the fish or by decreasing the rate of spread of the infection.

For eradicating the disease our only hope, and that a slender one, is to systematically remove all dead and diseased fish as soon as discovered. Patterson recommends that they be burned and *not buried*, since the organisms survive in the dead fish and may be carried again into the streams. Unless due to some undiscovered temporary factor, the disease is practically certain to appear again.

Whatever organism may be most responsible for the disease, the latter being an affection of the skin, will be influenced by other organisms as well, and there will also be a number of contributing factors, the chief of which will be those that lower the general vitality of the fish. In the case of the salmon retained for spawning purposes, an effort should be made in the future to improve the conditions in the ponds, particularly with regard to renewal of the water and the attainment of the most suitable temperature, so that the fish will be affected as little as possible. If the disease reappears, experiments should be instituted to determine the conditions best adapted to prevent its spreading.

The use of the fish for spawning purposes raises the question of the possible effect of the disease on the eggs or on the next generation. The Deputy Minister informs me under date of April 6, 1916, that in three hatcheries, supplied from the Miramichi retaining pond, the loss had already reached a figure of from 42 per cent to 61 per cent of the original number of eggs. It seems probable that many infected fish had recovered, as maintained by Mr. Sheasgreen, and that these gave eggs of greatly lowered vitality. The fish stripped were all in good condition, and precautions were taken to prevent any infection reaching the eggs from the exterior of the fish or from the pond.

What would be the result if some of the infection did reach the eggs? The *Saprolegnia* is known to attack fish eggs, but it is at least probable that this occurs only when the eggs are of low vitality. Also *Saprolegnia* spores are so widely distributed as to be present in the water in the hatching troughs in any case, although those from the fish may belong to a more virulent strain.

It is improbable that the bacteria, which may have a causal relation to the disease in the salmon, will attack the salmon eggs. Plehn (1911) found that *Bacterium salmonicida*, which produces furunculosis in the brown trout (*Salmo fario*) attacked neither the eggs, the alevins, nor the fry of the trout, but did attack the yearlings. It is therefore quite unlikely that the disease can be transmitted through the fry and by that means be carried to the streams in which fry from Miramichi eggs may be planted. It is possible, however, that it might be carried in the water used for shipping the eggs or fry.

It is very desirable that during a future season other rivers should be investigated. It has been claimed that in the rivers of Great Britain the salmon disease was present in a sporadic form previous to the outbreak in 1877.

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X

THE SMOKING OF "HADDOCKS" FOR CANADIAN MARKETS—AN INVESTIGATION CONDUCTED AT THE MARINE BIOLOGICAL STATION AT ST. ANDREW'S, N.B.

By Miss Olive Gair Patterson, M.A., M.B., University of Toronto.

1. INTRODUCTION.

The production of finnan haddie is an industry of some importance on the coasts of the Maritime Provinces. This importance, however, is not national, in degree, as it is on the Scottish coast. There is not the demand on the market for finnan haddie "Made in Canada" that there might quite well be, if it were made to become the equivalent of the Scotch article of diet in flavour and texture. The processes used in both countries are somewhat similar, it is true, being based on the original method used in the little Scottish town of Findon on the north coast. Variations were introduced by the different fish-curers, which were considered expedient or profitable to them, but at times detrimental to the culinary value of the fish, upon which followed a lowering of both the market value and the demand on the market for this excellent foodstuff. The point of first importance in the Scottish industry was the improvement of the flavour of fresh fish, and, of second importance, was the preservation of the fish. These are in the reverse order in the industry as developed in this country. Many of the markets are far distant, and flavour has been sacrificed to preservation, but often inferior, second-rate or slightly tainted fish are used in producing the finnan haddie, so that the quality of the finished product is poor or, at any rate, not to be relied upon. The best of the catch is put up for exportation on ice, fresh, and until these first quality ones are used to make finnan haddie, the Canadian market will not increase its demand for them, the consumer preferring to purchase the fresh fish off ice rather than the smoked one of doubtful origin and quality. It is surely the part of wisdom to create the demand on the market by first producing a more excellent haddie, and then to encourage fish curers to reach and keep up that standard of excellence.

2. SCOTTISH METHOD.

The method of producing finnan haddies, as practised in Aberdeenshire, the most important Scottish centre of the industry, includes the processes of splitting, salting, and smoking.

"The fresh haddock is first treated by removing the head, splitting, eviscerating, and then giving an extra cut behind the backbone from the right-hand side in order to expose to view and facilitate the curing of the thick muscles of the back. This supplementary cut does not extend to the tail. The fish is then salted for half an hour in strong brine, and, after draining, is ready for smoking".[1] Peat and sawdust are used in producing the smoke; the fish, which are placed on sticks in tiers one above the other, receive constant attention during their short stay of five or six hours in the dense smoke which the peat produces.

Smaller fish are cured separately, the time of both pickling and smoking being diminished so that the flesh does not become tough—on the contrary, these lightly cured small fish are a great delicacy.

The Canadian method of curing differs in some important essentials from the Scotch, besides varying in minor details.

[1] Excerpt from H. M. Smith's "Note, on Scotch Methods, etc." U.S. Commission of Fish and Fisheries, 1901.

3. CANADIAN METHOD.

(1) No vertebral cut is made after splitting. Bacteriological tests of the flesh under the backbone of finnan haddie only forty-eight hours old gave positive cultures of trimenthylamine-producing bacteria in many cases.[2]

(2) The smoke is produced by burning hardwood, preferably beech or birch. The smoke is, consequently, not so dense and the process has to be continued for a much longer period of time, fifteen to eighteen hours, when the fish is a rich golden brown colour, the edges almost brittle, and the flesh in the middle thick portions still moist and scarcely flavoured by the smoke.

(3) At times the fish are allowed to stand one to three days before curing, ostensibly to allow the blood to drain away, but this can be accomplished in one hour on ice, so that one fails to see the point of this lack of expeditiousness.

4. CONDITIONS ESSENTIAL FOR SUPERIOR PRODUCT.

The endeavour was made to determine, if possible, what were the optimum conditions for the production of finnan haddie *par excellence* on the coasts of the Canadian Maritime provinces. That these conditions would differ from the Scotch has been pointed out—for example, in the absence of peat as fuel, and the demands of distant markets; and under these latter circumstances a certain sacrifice of flavour to preserving property must be made, still, it is quite within the limits of possibility to so standardize the industry that these variable conditions would be altered to suit the requirements of the market for which the fish were destined.

These variable conditions are:—

(1) Time of the fish in brine.
(2) Quality of brine.
(3) Quality of smoke.
(4) Time of smoking.
(5) Method of splitting.

5. SCIENTIFIC TESTS OF CURING METHODS.

Most of these conditions were varied in the tests described below. The record of the flavour of the different haddies when cooked was made from the opinions obtained from several individuals to whom were given samples of the various products.

Experiment 1.—The first haul of haddock were cured according to the method used by certain of the New Brunswick curers—except that here, as in each test, perfectly fresh fish and of approximately the same size were used. That the fish should be of the same size and weight is important, as a comparison otherwise would be obviously inaccurate.

Experiment 2.—The fish in this lot were smoked for varying periods of time, the salting being constant.

Experiment 3.—In this the conditions were reversed. Smoking time constant and time in the brine varied.

Experiment 4.—Small fish were used and both conditions were varied to produce a delicately flavoured lightly-cured fish.

Experiment 5.—In this the preservative value of the salt content of the fish is shown and its limit, as far as palatibility is concerned.

Experiment 6.—In this the method is applied to the hake.

Experiment 7.—Proves the advisability of the dorsal incision.

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[2] Bacteriological examinations were made by Dr. F. C. Harrison, MacDonald College, and his report appears in the present volume of Biological Contriibutions.

Experiment.	Date.	Preparation.	Salting.	Smoking.	Remarks.
No. 1..	July 20. ..	Split abdominally—eviscerated—washed clean.	25 minutes' brine of sufficient concentration to float a fish. Then allowed to drain.	18 hours over slow hardwood fire.	Colour—dark brown—edges very dry—almost brittle.
No. 2..	August 2..	Split abdominally—eviscerated.	(a) 30 minutes as above.	6 hours over old wood to which was added creosote.	Colour -light brown. Flesh—soft. Flavour delicate.
			(b) 30 minutes as above.	15 hours..	Colour darker.
				"	Flesh—firm. Flavour excellent. Preserved 4 days.
No. 3..	August 4, one dozen large fish ¾ lb.	Split abdominally. Eviscerated. Kept on ice overnight—Well washed.	(a) 30 minutes..	18 hours	Excellent flavour. Flesh not tough not too salty.
			(b) 2 hours..	18 hours.. .. .	Flesh too salty but not toughened Salt could be removed by previous soaking.
			(c) 4 hours..	18 hours	Texture too tough. Preserved 17 days at 10° C.
No. 4..	August 10, one dozen small fish ½-1 lb.	Opened dorsally given the extra cut along the vertebrae.	(a) 15 minutes..	(a) 1. 5 hours. ..	1. Insufficiently flavoured.
				2. 10 hours.	2. Still moist—flavour delicious.
				3. 15 hours.	3. Flesh crumbly—did not hold together in cooking. Preserved nine days.
			(b) 30 minutes..	(b) 10 hours..	4. Flavour not so good as when salted 15 minutes but flesh firmer and of better keeping quality
No. 5..	August 10.	As above. ..	(c) 1 hour..	(c) 1. 10 hours . .	Flavour—somewhat coarsened texture—otherwise good. Excessive salt removed by three washings previous to cooking—20 minutes.
				2. 15 hours..	Flavour—about the same as above. Preserved—8 days to 20. Texture coarsened somewhat.
No. 6..	August 18, ten small hake.	Split abdominally.. ..	(a) Salted ½ hour..	About 10 hours until brown colour.	Flavour—inferior to haddock but reasonably good.
				Very windy day ..	Texture—inferior to haddock, but reasonably good.
			(b) Salted 1 hour	" " ..	Too salty—much too long for these fish which are thinner than the haddock.

Details of Experiment 7.—Estimations of the NaCL content of the fish muscle and inner portions to determine approximately how much the flesh under the backbone absorbed within a given time. The portions were extracted with 10 vols. water for three hours with frequent stirring—10 c.c. of the boiled filtered extract were used in the estimations.

Exp. No.	Sample.	c.c. N/11 silver nitrate used.	Equivalent in grams NaCl.	Per cent in moist muscle.
83	Salted ½ hour, flesh under bone..	1·965 c.c.	0·01965	1·965
84	Salted 2 hours, flesh under bone.	2·5 c.c.	0·025	2·5
87	Salted 4 hours, flesh under bone.	8·26 c.c.	0·0826	8·26
86	Salted 4 hours, flesh from surface	11·05 c.c.	0·1105	11·05

Obviously, this table shows that it takes some four hours for the flesh under the bone to approximate that of the external portion of the flesh in salinity, and affords a strong argument for the exposure of the back muscle to the saline by making the vertebral cut.

6. CONCLUSIONS.

(1) The splitting of the fish in the usual way, but also making an additional cut along the vertebral column is the most effective method of preparation.

(2) The fish are freed from blood by allowing to remain on ice 1 to 2 hours. They should then be washed freely with fresh water.

(3) Small fish should not be salted more than 15 minutes. Larger fish up to four pounds should not be salted more than one hour if the texture of the fish is to be preserved, and half an hour is the optimum length of time in saline for the flavour of the fish.

(4) Ten hours over a beechwood sawdust, or old-wood smoke produced a deliciously flavoured fish. Fifteen to eighteen hours browns and dries the fish and aids in its preservation by more thorough drying.

These conditions should be altered to suit the market, the more lighty cured fish being utilized in the home markets and the heavier-salted for the distant ones. The chief condition to be emphasized, however, is the utilization, for the production of finnan haddie, of first-class perfectly fresh haddock, and the keeping of it cold after it is prepared.

XI.

SOME OBSERVATIONS ON HADDOCKS AND "FINNAN HADDIES" RELATING TO THE BACTERIOLOGY OF CURED FISH.

By Principal F. C. Harrison, D.Sc., Macdonald College, P.Q.

During the month of July, 1915, the writer whilst at the Biological Station, St. Andrews, N.B., examined bacteriologically the intestinal content of twelve haddocks. The haddocks were caught about a mile to two miles from the station, were brought to the laboratory, opened, and a portion of the intestine ligatured and removed. An opening was then cut into the piece with sterilized scissors, and a heated platinum needle thrust in, and the small amount adhering to the needle was transferred to about 5 c.c. of sterilized water and thoroughly shaken.

Plates were made from the dilution, from 1 to 3 œse being used for each plate. Plates were made with:—

Haddock sea water gelatine	12 per cent.
Beef peptone sea water gelatine	12 "
Lactose litmus sea water gelatine	12 "

In this manner the intestinal content of twelve fish was plated, and a large number of isolations made.

At the same time a microscopical examination of the intestinal contents was made. Smear preparations invariably showed numerous bacilli, mostly small forms, no cocci and no spirilla. The bacterial content of the twelve fish was similar. Ten different species of bacteria were isolated; of these four were liquefiers, and about 25 per cent of the total number of colonies from each fish belonged to this group. Many of the plates gave a strong odour of trimethylamine, and one or two of the pure cultures gave this odour. In the mixed cultures, however, in the plates the odour of this substance was much stronger.

The most common organism which was found in eight of the twelve fish was a small bacillus, motile, producing small depressions in gelatine plates, with numerous smaller colonies around the edge, rapidly liquefying, producing H_2S, indol, and trimethylamine, gas in glucose, but not in lactose, coagulating milk with digestion, and in short appearing to be closely related to *B. vulgaris* (Hauser).

This organism has the greater interest of all those isolated because it was found subsequently in the flesh, and on the surface of smoked haddock (finnan haddie) cured at the station, and also from some spoiled haddock received from a packer.

A short account of the methods employed in securing the fish may be of interest.

The fish were caught near the biological station, and as soon as landed they were split, salted for one and a half hours in brine of sufficient density to float the fish, and smoked for eighteen hours. For six days after smoking the fish were kept in the laboratory at a temperature ranging from 60° to 70° F., and then pieces were removed from different parts of the dried fish, each piece was thoroughly scorched and dropped into flasks containing haddock sea-water peptone broth.

Other pieces of fish were obtained thus: The backbone was cut near the tail, carefully raised, and a portion of the flesh beneath was cut out with a sterilized knife, the piece seized with sterilized forceps and held in the flame until well scorched on the outside, and then dropped into a culture flask.

All flasks thus inoculated were held at room temperature; twenty-four hours later all showed turbidity. Gelatine and agar plates were made from the various flasks, and the colonies which developed were isolated in the usual manner. From this source a number of organisms were secured, and of these four were similar to those previously obtained from the intestinal content of fresh haddies.

In October, 1915, a circular of inquiry was sent to a number of fish dealers and, in response to a request for spoiled fish, a box of spoiled "haddies" was received during the course of the winter. They were covered with a semi-slimy growth, giving a watersoaked appearance. At numerous places there were whitish points resembling bacterial colonies. The flesh was somewhat softened, and the fishy odour much intensified.

From gelatine plates made from this fish the writer secured the liquefying bacillus already mentioned, and large numbers of *Torulæ*.

The most significant fact, therefore, in this piece of work is the presence of liquefying bacteria belonging to the *B. vulgaris* group in the intestinal canal of fresh haddock, and the presence of this organism on and in the flesh of smoked haddocks, and smoked haddock that were spoiled.

The amount of salt and the duration of the smoking period to produce finnan haddies of good flavour are not sufficient to kill the organisms present on the fish after they are gutted, and the antiseptic action of salt and smoke is not sufficient to inhibit the slow growth of organisms.

The writer, after studying the methods of curing haddock, has been impressed with the general carelessness displayed in allowing fish to remain for many hours exposed to warm air and sunlight before gutting and salting. True, that these observations were made under summer conditions when comparatively few haddocks are cured; but the effect of such treatment results in a large increase in the number of bacteria present on the fish, and consequent quicker spoiling of the smoked article.

In winter these conditions would be better, and although the writer has never had the opportunity of studying winter conditions, he has been impressed by the great difference in flavour between fish salted and smoked at the biological station during the winter of 1915-16, and those bought from various dealers in Montreal.

From one or two experiments on the percentage of dry matter, total ash, and chlorides as NaCl made on a few fish sent to this laboratory, the writer suggests that such determinations should be made of a series of fish for which the amount of salt used, the salting and smoking period were known.

Further, from the bacteriological standpoint some work should be done on haddock smoked under winter conditions.

MAY, 1916.

XII

THE BACTERIOLOGY OF SWELLED CANNED SARDINES.

By Wilfrid Sadler, M.Sc., B.S.A.

Introduction.

In a survey of the literature relating to the bacteriology of "canned fish" it is found, with a few exceptions, that the investigations recorded have been undertaken in connection with proved and alleged cases of food poisoning. Consequently the data available are largely interrelated with data on the bacteriology of canned meats, and of ordinary meats as supplied unpreserved. The exceptions of which I have knowledge are the investigations of Prescott and Underwood (1897)[1] on "Micro-organisms in the Cannery Industries"; the work of Macphail associated with Bruére (1897)[2] on "Discolouration in Canned Lobsters"; and the recent work of Obst on "A Bacteriological Study of Sardines" (1916)[3]. Prescott and Underwood working on cans of spoiled clams and lobsters isolated species of bacteria, two classed as micrococci, the other seven as bacilli. The investigators found the cans to be badly decomposed, in some cases almost entirely liquefied, much darkened in colour and of a very disagreeable odour.

Of the bacilli, six coagulated and digested milk, while none of the seven produced gas in sugar solutions. According to the descriptions given, certain of these cultures bear a close resemblance to some recorded by me among the organisms in class II on pages 211-213. Both strains of micrococci isolated by these workers failed to coagulate milk, and failed to produce gas in sugar solution. The bacteria were not named.

Macphail and Bruére[2] in their work on lobsters isolated and recorded the features of four strains of bacteria; two were cocci, and two were fine rods. Each of the four were inoculated into sterile cans of lobster, and in due course the rules of proof were satisfied. Some of the organisms I have isolated —Class I—bear a resemblance to certain of the strains described by Macphail and Bruére, but it is impossible to express a definite opinion as to their mutual identity.

Obst[3] in the report of her investigations on "A Bacteriological Study of Sardines" states that a bacillus, designated "Bacillus A", has been found in pure culture in two hundred and eighty-seven swelled sardine cans. The organism is a spore-former*
hundred and eighty-seven swelled sardine cans. The organism is a spore-former*
and according to Obst is possibly identical with *B. Walfischrauschbrand* (Ivar Nielsen).[4] The only reference I can find to the bacillus of Nielsen[4] fails to give full cultural details. In the fall of last year I was in communication with Mrs. Obst, but at that time her report was not available; as I have received no copy I consider it probable that it is not yet published. From the reference cited[3] which extracts a recent paper read before the Society of American Bacteriologists I am unable to compare any of my strains with the "Bacillus A". The reference does not mention the thermal death point in laboratory media, but states that the organism after inoculation into cans of sardines survives bathing in boiling water for 1½ hours. With the strains described in my report no experiments under commercial conditions have yet been conducted. For the present I am not justified in going further than to state that based on such information as is available, it is improbable that the strains isolated by me are identical with the "Bacillus A" of Obst.

The relationship of bacteria to sardines was discussed by Auche[5] (1894), but the paper is not available.

* In the strains I have isolated Class I, no evidence of spores has been demonstrated.

The association of mussels with food poisoning is cited by Vaughan, 1892[6]; citing from Vaughan's paper:—

"That chemical poisons may be transmitted from the lower animals to man in the food is shown by the history of poisoning with mussels and with fish. As early as 1827 Combe described in detail the symptoms induced by the eating of poisonous mussels, and a valuable contribution to the same subject has recently been made by Schmitdmann, who has found that non-poisonous mussels placed in the water of Wilhelmshaven soon became poisonous, and that the poisonous mussels from the harbour soon lose their harmful properties when placed in the open sea. Linder has found in the water of this bay and in the mussels living in it a great variety of protozoa, amoeba, bacteria, and other low forms of life, which are not found in the water of the open sea, nor in the non-poisonous mussel. He has also found that if the water of the bay be filtered, non-poisonous mussels placed in it do not become poisonous. He therefore concludes that poisonous mussels are those which are suffering from disease due to residence in filthy water."

In view of the close relationship to mussels of clams, a variety of shell-fish canned in both New Brunswick and Maine, U.S.A., the observations of Linder cited by Vaughan are of considerable interest. In the same paper Vaughan describes the case of one of his own patients who showed poisoning symptoms after eating freely of canned salmon. The patient under treatment recovered. Vaughan submitted the remains of the salmon to various tests and found an organism which he describes as follows:—

"The only germ which could be found, either by direct microscopic examination or by the preparation of plate cultures, was a micrococcus, and this was present in the salmon in great numbers. This germ grew fairly well in beef-tea, but the injection of five cubic centimeters of the beef-tea culture of different ages failed to affect white rats, kittens or rabbits. However, this micrococcus when grown for 20 days in a sterilized egg, after Hueppe's method of anaerobic culture, produces a most potent proteid poison. The white of the egg becomes thin, watery, markedly alkaline, and 10 drops of this suffices to kill white rats.

"Evidently in the preparation of the salmon this can was not sterilized; it was sealed, and for months, possibly longer, this germ had been growing anaerobically, and elaborating a chemical poison."

Savage, in England who has investigated many outbreaks of food poisoning, has isolated *B. enteritides* from tinned salmon. Griffiths, cited by Vaughan and Novy[8], claims to have isolated a ptomaine *saordinin* from sardines.

In view of the types of bacteria I have isolated in the present investigation, it is of importance to note that Poels[8] in Rotterdam has isolated varieties of *B. coli* from cases of food poisoning due to the eating of meat from a supposedly healthy animal. McWeeney[9] considers that meat poisoning outbreaks are due to organisms of the following groups:—

(*a*) The *Typho coli* group, including *B enteritides* (Gaertner).
(*b*) The group of putrefactive aerobes (*Proteus,* etc.).
(*c*) The obligate anaerobes *(B. botulinis).*

It will be seen, pages 192, 209, that of the organisms I have isolated, some strains are varieties of the *Proteus* group, and some varieties of the *B. coli* group. Vaughan and Novy[8] describe the most common form of food poisoning that caused by contamination of foods with saprophytic bacteria; such bacteria either before or after the food has been eaten, elaborating chemical poisons.

PRESENT INVESTIGATION.

The investigation herein described of the "Bacteriology of Swelled Canned Sardines" has been undertaken on behalf of the Biological Board of Canada. The work was commenced in the summer of 1916 at the Marine Biological Station, St. Andrews, N.B., and has since been continued in the laboratories at the college. To the canners the appearance of "swells," as they are termed, in the cases of canned fish sent out from the factories is a matter of considerable concern. The desirability of undertaking experimental work in the hope of eliminating any risk of cans developing the swelled condition, occurred to the principal of Macdonald College, Dr. F. C. Harrison, in the summer of 1915. At that time Dr. Harrison was engaged at the marine station, St. Andrews, in the examination of haddock attacked by a bacterial disease, and it was while conducting this investigation that the problem discussed herein came under his notice.

The matter was brought to the attention of Dr. A. B. Macallum, secretary of the Board, and in due course it was my good fortune, on the recommendation of Dr. Harrison, to be asked to take up the work. The procedure to be adopted was left entirely in my own hands. Dr. Macallum, and Dr. A. G. Huntsman, curator of the marine station at St. Andrews, have throughout given me every encouragement, and the greatest possible help in every way which seemed likely to assist in the elucidation of the problem.

On arriving at the station in July, the necessary arrangements were made by Dr. Huntsman enabling me to visit a number of the New Brunswick canning factories. Later it was made possible for us to visit several of the largest plants operating in the State of Maine. I was thus brought into close touch with the industry of canning as a commercial undertaking, had exceptional opportunities of seeing the methods of packing as generally adopted, and accumulated a store of information as a result of discussions with the canners themselves. Factories were visited which were engaged in the canning of herring, sardines, haddock, and clams, respectively. It is hardly necessary to say that the sardines of New Brunswick and the State of Maine are small herrings. It was apparent that the canning factories were principally concerned in the packing of sardines; and while both during the summer and since returning to the college, swelled cans of sardines, herring, haddock, lobster, and shrimps have been gradually accumulating, the work has up to the present been confined entirely to sardines and possible influences affecting the same. After nine months' work, I find that I have been able to do little more than touch the fringe of the problem, considered as a whole. The report here presented therefore is principally concerned in recording the work accomplished up to the present, such conclusions as it is legitimate to draw at this early stage, and such information as to methods and media used in the laboratory as will make the work of some service to the continuance of the investigation.

Under the circumstances I do not propose to enter into a detailed description of the equipment, methods of treatment and system of packing of the fish, and general procedure of the factories engaged in the canned fish industry; such will be more appropriate when the work has progressed to a more advanced stage. The one phase of the canning process of which brief mention must be made at this point is the temperature employed in the so-called sterilization of the cans when packed and finished. As the most common size of can produced from all the factories is one weighing from 3 to 4 ounces, the temperatures given shall be those applied to cans of this size.

In the majority of the factories visited, the cans are immersed in baths of boiling water for a period of 1½-2 hours. That completes the heating process. Briefly the essentials of the treatment of the fish—which have been salted in the boats as taken from the weirs,—on arrival at the factory is as follows: immersed in a mixture of sea-water and salt for 1 to 1½ hours; spread on racks, termed flakes, in thin layers, and for 10

minutes placed in flowing steam; dried in room through which hot air is continually circulated, for 1 hour; heads discarded and the remainder of the fish arranged in the cans; oil automatically added, and tops put on, and fastened by either the "rolling" or the "pressing" process. The cans are then heated as specified above. In some factories the preliminary steaming for 10 minutes is dispensed with, and a continuous progression through a bath of cottonseed oil at a temperature of 200° C. is substituted, this occupying 2 to 3 minutes.

In one factory where the fish are fried in oil for 3 minutes or so, the final heating is done under pressure at a temperature of 225° F. for a shorter period.

It should be added that in all the sardine factories visited, the most careful supervision is exercised in the final packing of the cans in cases before shipping. Each individual can is rapidly passed through the hands of an expert "tapper" who discards cans displaying any irregularity, such being reprocessed or entirely discarded.

The project of the investigation may be logically stated thus: "Essentially to determine whether or not the swelling of the cans is due to the activities of bacteria." If on examination, and when submitted to suitable cultural methods strains of bacteria are isolated, the procedure to be as follows:—

1. Purify and obtain in pure culture.

2. Determine the morphological, biological and biochemical characteristics of the organisms.

3. Inoculate the strains obtained in pure culture into normal cans and record condition at stated intervals.

4. Treat "control" normal cans in a similar manner except for the inoculation with the culture.

5. If swelling occurs in the inoculated cans, and no change is noted in the "control" cans, the presumption is raised that the swelling is due to the organisms used for inoculation.

6. Examine the "swelled" cans and determine in culture the presence or absence of bacteria.

7. If bacteria are found, purify and compare culturally with the strains used for inoculation.

8. If on comparison the strains be found culturally identical with those used for inoculation the cause of the "swelling" has been established; and experimental proof has been obtained to warrant the statement "that the swelling of the cans is due to the activities of bacteria."

The data recorded in this report show that up to this point, the work has been successfully accomplished in so far as concerns certain strains of bacteria; and the "Postulates of Koch" have been satisfied.

While at the biological station, I not only visited the factories as already stated, but many swelled cans of sardines were secured, and a number of organisms in the cans isolated in culture. An attempt was also made to discover the source of the organisms. Samples of sea water taken from the weirs, samples of oil and tomato sauce as used in the packing, intestines of fresh herrings, and the excreta of herrings were obtained. No organisms were found in the oil; the tomato sauce in sealed receptacles as imported from Italy has still to be examined; but from the sea water, herring intestines, and herring excreta several strains of bacteria were isolated. These, with those I found in the sardine cans, I brought back on my return to the laboratory here. During the succeeding months a number of the cultures have died out, and those remaining from sea water, herring intestines, or excreta, fail to produce gas in carbohydrates.

For the sake of convenience I have divided the strains of bacteria isolated at St. Andrews and at various times during the fall and winter into two main classes:—

Class I.—Gas-producers.
Class II.—Non-gas-producers.

For obvious reasons my attention has been principally confined to the gas producers, Class I, and it is to the descriptions of these that the cultural part of the report is chiefly directed.

Regarding the influence of those organisms included in Class II on the condition of the fish in swelled cans, I am not in a position to express any opinion. Many of them have, however, been submitted to certain preliminary tests, the results of which are recorded, pages 211-213. Beyond this I have not gone, and no comments respecting the class are made.

Concerning the gas-producers, Class I, 8 strains have been described morphologically, biologically and biochemically. The detailed descriptions are found on pages 192-207. On pages 208 and 209 a summary arranged in tabular form is shown.

The number of cultures described in Class I, and those more briefly referred to in Class II, bear no relationship to the total number of cultures isolated in the course of the work. As was to be expected, preliminary tests of a differential nature revealed the fact that many strains were in duplicate, and sometimes even in triplicate. By repeated series of tests the duplicates or triplicates were gradually eliminated. In the pages devoted to the cultures in Class II, pages 211-213, a note is added as to the comparative frequency of the respective strains. In eliminating strains from the cultures in Class I, greater precautions were taken on account of their closer relationship to the abnormal condition of the cans. Some of the final cultures described represent the individual strains, after the elimination of as many as four or five strains which had been found to have the main characteristics in common. Three cultures of Class I were finally eliminated to avoid duplication in description, just prior to the preparation ot the manuscripts, these being identical with cultures, 34, 37, and 64, respectively.

To continue the statement as to the project of the investigation, initiated on page 184, it is further required, that in order to confirm the work up to the present and complete the investigation it is desirable:—

9. That many more cans shall be examined and the contents cultured.

10. That if possible the source of the responsible organisms be determined, and also the stage at which infection takes place.

11. That experiments be conducted both under laboratory conditions, and under conditions prevailing in the canning factories, with a view to determining the most satisfactory means of eliminating "swelling."

12. That possibly the pathogenicity or degree of pathogenicity of the strains proved responsible for the "swelling" be determined by inoculation into suitable laboratory animals.

Arrangements have been made by Dr. Huntsman whereby during a later season I shall have opportunities of determining if possible the source or sources of the causal organisms of the swelled condition of cans of sardines.

The future scope of the laboratory work will necessarily include examination of swelled cans of other varieties of fish, including those of which mention is made on page 183.

When visiting the canning factories last summer the manager of one of the largest of these told me that a pressing problem with which he had to contend was the frequent appearance among sardine cans of what are termed "sour flats." The condition is one of which there appears at present to be no satisfactory explanation. The product is rendered unmarketable, and the condition is one which cannot be detected until the cans are opened.

MEDIA EMPLOYED.

In this investigation I have used media prepared from fish concoctions, the ordinary laboratory media, and certain special media. In the early part of the work when experimenting with methods prior to the adoption of a definite procedure, difficulty was experienced in growing some of the strains isolated. The colonies developing on some of the plates at this time were too small to be subcultured. I therefore utilized the marine resources at hand and prepared media from fresh herrings, from clams, and from seaweed, using fresh sea water instead of tap or distilled water. It was found later that the organisms which necessitated this media were those I have put in the main Class II, the non-gas-producers. After successive subculturing in the laboratory these same strains have grown moderately well on the usual standard media.

The organisms of my main Class I, the gas-producing strains, have grown well in the standard media. The growth of some strains has been more luxuriant on herring media or clam media, but the use of such has gradually been eliminated for two reasons:—

(1) the satisfactory growth obtained on standard media, and the convenience of its use;

(2) the necessity of using the standard media in order to compare the strains isolated with varieties already described in literature.

Herring Broth.—Fresh herrings obtained direct from the weirs were washed in running water and ground up, no portions discarded, through a meat grinder, mixed with sea water, 1 part ground herring to 1–2 parts sea-water, and heated for several hours in the steamer or autoclav. The mixture was allowed to cool and the fat skimmed off; again heated, and strained through cheese cloth. The strained liquid served as the standard herring extract. Varying strengths of broth were made up, good results being obtained with the following mixture:—

500 cc standard broth,
1,000 cc. sea water,
15 grams peptone.

The ingredients were heated together in the steamer, neutralized with n/20 NaOH to + 10 (phenol phthalein indicator), cleared with white of egg, tubed and sterilized in the usual way.

Herring Agar.—To 500 cc. of the standard broth, mentioned above, were added 500 cc. or 1,000 cc. sea-water, peptone at the rate of 1 per cent and agar at the rate of 1·2 per cent; the whole heated together until ingredients dissolved, neutralized to +10, cleared with white of egg, filtered, tubed and sterilized in the usual way.

Clam Agar.—Fresh clams were dug up on the bench, washed in running water, opened and ground through meat grinder; to this was added sea water at the rate of 1 part clams to 2 parts sea water, and the whole heated for several hours in steamer or autoclav. The stewed mixture was strained through cheese cloth; this filtrate constituting the standard broth. To 500 cc. of the standard broth were added 1,000 cc. sea water, peptone at the rate of 1 per cent, and agar at the rate of 1·2 per cent; the whole heated together until ingredients dissolved, neutralized to +10, cleared with white of egg, filtered, tubed and sterilized in the usual way.

I have also steamed clams in the shell in sea water, approximately weight for weight; retaining the juice which has a typical "sheen"; then after opening the clams using them as described above.

In the earlier part of the work the medium was used successfully to some considerable extent; and in comparison with standard beef peptone agar it appeared to exercise a selective action towards certain strains of bacteria

obtained from various sources. This in all probability would be due to the glycogen content. While the use of this medium has for some time been discontinued, I propose to test its value for certain phases of the laboratory analyses.

Baur[10] in working at Kiel on the denitrifying bacteria used and recommends a broth of which mussels are the essential component.

Beef Peptone Agar.—Standard methods.[11]

Beef Peptone Gelatine.—Standard methods.[11]

Glucose Agar.—One per cent glucose added to agar prepared as above, immediately before tubing.

Löeffler's Blood Serum.[12]

Loeffler's Typhoid Solution [13].—This medium containing malachite green has been recommended by Löeffler for use in culturing strains of the *colon-paratyphoid-typhoid* group.

Acsculin Agar[14].—For specific reaction of organisms of the *colon-aerogenes* group; loops of a broth culture spread on plates.

MacConkey's Neutral Red Bile Salt Lactose Broth [15].—For reduction test of organisms of the *colon-aerogenes* group.

Bouillon for Voges-Proskauer Reaction.[16]

Bouillon for Methyl Red Reaction.[17]

Solution for Reduction of Nitrates to Nitrites [18]. Giltay's synthetic solution was used.

Dunham Solution for Indol Production.[19]

Glucose Broth.—One per cent glucose in Dunham solution.

Fermentation Broths.—For the fermentation reactions I have used ten test substances. It will be seen that in addition to the glucose *salicin* I have adopted the use of another glucoside *aesculin*—used in conjunction with iron citrate by Harrison and Vanderleck—as a fermentable test substance in Dunham broth. I have been using aesculin for this purpose during the last four months in connection with work on the gas producing organisms in the Ottawa river water, and find a correlation in the black reaction of the aesculin agar medium, and the production of acid and gas in aesculin used as a carbohydrate test substance.

Litmus Milk.[20]

METHODS.

On account of the comparative paucity in the literature, of descriptions of actual methods adopted in the isolation of bacteria from swelled canned fish, the procedure I have followed has largely been determined by experience as the work has progressed. This procedure has been changed as better methods suggested themselves, and in the culturing from the many cans still awaiting examination I propose further changes affecting detail, while the use of additional media which will be to the advantage of the work has suggested itself.

Isolation of Bacteria from the Cans.

The oily greasy surface characteristic of the cans with pronounced swelling necessitated the use of a disinfecting agent which would disinfect, and remove the oil, at the

same time. Absolute alcohol has proved to be simple in application and quite satisfactory. The cans were first cleaned with a weaker alcohol (70 per cent to 90 per cent) then thoroughly treated with the absolute alcohol. Can openers, forceps, and dissecting scissors were immersed in alcohol and flamed immediately before use. When a sufficiently large aperture had been made in the can, pieces of fish and a portion of the oil or sauce were removed with forceps and pipettes and inoculated into tubes of liquid medium.

At the commencement, it was at once obvious that direct plating from the cans would not be at all satisfactory on account of the oily nature of the contents; liquid media have therefore been used for the first inoculation from the cans, the procedure having the additional advantage in that such media serve as enrichment fluids. I first used peptone broth (Dunham), herring broth, and nutrient broth; later, the addition to the series of glucose peptone broth proved to have advantages. As a result of the additional knowledge provided by a study of the strains of organisms already worked out, it will be desirable in further work to use media having differential qualities for the first inoculations; in addition to the broths already in use.

The tubes were incubated at 37° C. except during the six weeks spent at St. Andrews, when all cultures were kept at room temperature. The broths were examined in 18-24 hours for growth; if no growth were apparent, further incubation was resorted to; if growth could be noted, series of plates were made. The preliminary incubation in broth tubes had the additional advantage to those already mentioned, in that the oil had risen to the surface leaving the sub-surface liquid comparatively free. Finely drawn out pipettes with the finger over the end were passed through the layer of oil, and the culture fluid drawn up. After suitable dilutions had been made, plates were poured using herring agar, clam agar, beef peptone agar, and glucose agar; in the more recent work glucose agar being used almost solely. The plates were incubated—temperatures as aforementioned—and when growth was sufficient, those colonies most common were streaked on agar slopes; from these the necessary purification by plates being made.

NOTE.—The preliminary incubation in broth tubes was in some cases, but not always, duplicated aerobically and anaerobically.

The following apply to the main Class I:—

Microscopic examinations.—The microscopic preparations were uniformly made from beef peptone agar slopes incubated 18 to 24 hours at 37° C.

**Gram's Stain.*—The gas-producing organisms, Class I pages 192-207. display an unusual degree of resistance to decolorisation with alcohol in the Gram method of staining. When treated by the usual method,—decolorisation with alcohol until no further colour can be washed out,—each of the eight strains recorded would be classified as Gram positive. The shade of violet is not as deep as that which is typical of the classic Gram positive reaction, but the result is much nearer positive than negative. On prolonged soaking in absolute alcohol, 30 to 40 minutes, the reaction is definitely Gram negative. Films made from a typical Gram positive lactic acid producing organism withstood the decolorisation with alcohol for 40 minutes

The organisms herein discussed should therefore be described as Gram negative, displaying an unusual degree of resistance to the decolorisation with alcohol.

Motility.—Hanging drops for these tests were made from the water of condensation, agar slopes; young cultures incubated at 37° C., never longer than twenty-four hours.

Inoculation of Media.—All tubes of media used for the determination of cultural features and biochemical reactions were inoculated from young peptone broth cultures of the particular organism. The use of peptone salt solution instead

of nutrient broth eliminated to a minimum any risk due to the presence of muscle sugar. It may be mentioned that repeated tests for the presence of muscle sugar in the peptone used gave a negative reaction based on the absence of acid and gas; the tubes being inoculated from an active strain of the *B coli* group.

Prior to the inoculations of the series, peptone broth tubes were inoculated from agar slopes, and incubated at 37° C. After 18 to 24 hours, usually about 20 hours, the whole series of media would be inoculated with the broth from a 1 cc. pipette; 2 to 3 drops of culture to each tube. Slopes of solid media were streaked with a standard 3 mm. loop platinum needle. The number of tubes involved and the amount of test substances necessitated have been considerable throughout the work, and to insure economy of expense and time, strictly quantitative estimations of the gas evolved have not been carried out other than by means of the Dunham tube. In view of the method noted above, however, the results are truly comparative throughout. Moreover, for the particular purpose of the present work the essential point to be decided regarding the fermentation of the test substances to gas is this—does a particular culture produce gas, or does it not produce gas? It is not only of considerable interest, but of much practical and classificatory value to know whether the amount of gas produced in a given time at a given temperature from a given substance is great or small. Such information can be comparatively well shown by the use of the Dunham tube.

Indol Production.—The tubes to be tested for Indol were incubated at 37° C. for 7 days; the Bohme Ehrlich test being used.

Reduction of Nitrates.—The Giltay solution was tested after 3 to 4 days incubation at 37° C., for the presence of nitrites. The sulphanilic acid and a-naphthylamin reagents were used.

Voges Proskauer Reaction.—After 48 to 72 hours incubation at 37° C. the culture tested with a strong solution of KOH. The test if positive has usually shown the typical eosin shade in the upper layers, within 2 hours at room temperature.

Methyl Red Reaction.—Determined after incubation at 37° C. for 48 to 72 hours.

Cans of Sardines.

General Description. Appearance of Cans and Conditions of Contents.

Owing to the varieties of "brands" of sardines produced by the canning factories, the various methods of packing adopted, and the different substances utilized for the giving of flavour and consistency to the finished product, it is not possible other than in a general way to described the conditions met with in my examinations.

Normal cans.—In outward appearance there is a complete absence of any "bulging"; the top and bottom are either quite flat or almost imperceptibly concave. On shaking, there is no "rattle" and scarcely any movement of the contents can be heard. When opened with the cutter, there is no expulsion of air or gas, with little if any exuding of the oil or other material used in the process of packing.

The contents are firm, not macerated, and often white in colour; this last, however, depending to some extent upon the materials used in the packing. The smell is mildly characteristic of the fish, qualified by the variety of oil or tomato sauce used. There is in appearance and odour a complete absence of putrefaction. The fish are saturated to a greater or lesser extent with the oil, sauce, or other flavouring agents used, but without losing their firm and solid condition. The oil or sauce will be seen as a layer over and in the interspaces between the individual fish, rather than actually within the bodies.

Swelled Cans.—Outwardly the cans vary from a slight "bulged" appearance to a more pronounced swelling. The top and bottom are forced out as a result of the pressure, and present a decided convex surface. As the swelling becomes greater the oil or sauce will be forced out between the soldered parts of the can, and in pronounced cases the outside surface is greasy and wet, and possibly covered with the oil or sauce. Swelled cans, when shaken, have a characteristic "rattle" on account of the extra space within, resulting from the swelling. When the cans are opened, gas is expelled, accompanied in advanced swellings by portions of the liquid contents. In advanced cases there is a tendency for the oil or sauce to pour out over the surface of the cans.

The condition of the contents varies considerably. Usually the fish are macerated, disintegrated, and soft, and are intermixed with the oil or sauce; they have lost their entity. The odour is variable,—frequently it is not unpleasant, resembling to an accentuated degree the natural smell of normal sardines. In other instances a pronounced putrefactive odour is evident. It may be that the putrefactive odour is present at all times and is masked by the spices or other ingredients of the sauce. That is a point which can only be definitely pronounced upon after a more extended investigation.

CANS EXAMINED.

Up to the present I have examined forty cans, normal and swelled. The cans have been obtained personally or by express:

(1) direct from various canning factories in the province of New Brunswick and in the State of Maine, U.S.A.

(2) From the Health Department of a city in the Maritime Provinces.

(3) From retail grocery stores.

Many of the normal cans, representative of the various factories, proved to be sterile; from some have been isolated spore forming bacteria, inactive on fermentable carbohydrates,—see page 211. Culture 21 and in no instance have gas producing organisms been found.

From certain of the swelled cans I have isolated a variety of strains of gas producing bacteria, none of which show evidence of spore formation. The cans from which these strains have been isolated are representative of three of the factories engaged in canning; and for the sake of clearness these factories have been specified as *Packer A*, *Packer B*, and *Packer C*, respectively. Further, from swelled cans I have also isolated strains of bacteria which fail to ferment any of the carbohydrates used as test substances (pages 212-213). It remains, therefore, to be added that from some cans apparently "swelled" I have failed to isolate gas producing bacteria.

As already stated (page 185) the organisms isolated from the various sources have for the sake of convenience been arranged in two main classes:—

Class I.—Gas producers.

Class II.—Non gas-producers.

The gas-producers (see pages 192-207) have been isolated solely from swelled cans of sardines. Of the swelled cans examined the majority were obtained from sources 1 and 3 (page 190). Some were submitted by source 2. Under the circumstances it has seemed desirable to use some means of differentiation. Accordingly the swelled cans obtained: (1) from the canning factories, and (3) from retail grocery stores have been designated "Swelled cans, Series I"; those submitted by (2) a certain City Health Department, "Swelled Cans Series II."

Swelled Cans, Series I.

Can. I, Packer B.—Obtained direct from canning factory; packed with tomato sauce; characteristic "swelled" appearance. The pressure of the gas was so great that on the can being opened part of the contents were strewn over the laboratory bench. The odour was pleasant, though pungent, and may best be described as the natural smell of normal sardines accentuated. It is of interest to note that the plates made, using herring agar, rapidly developed at room temperature a putrid smell resembling, as expressed by a laboratory colleague, that of an "oriental latrine."

See Culture 32, Class I.

Can. II, Packer A.—Obtained from a retail grocery store; packed in cottonseed oil; same brand as those of "Swelled Cans, Series II". This can was passed as saleable and normal by a reputable salesman, and on personal examination of his stock I retained it as suspicious. I have no knowledge as to the date of packing. In appearance the can was slightly swollen, convex, but there was no evidence of oil exuding due to pressure of gas. On opening, a perceptible amount of gas was forced out. The contents were soft and desintegrated; colour slightly darker white than normal; odour an accentuation of the normal.

See Culture 34, Class I.

Can III, Packer A.—Source and brand as Can II of this series. This can submitted to me by the salesman. The appearance of the can, the appearance, condition, and colour of the contents identical with description applied to Can II.

See Culture 35, Class I.

Can IV, Packer B.—Source and brand as Can I of this series. In this can the swelling had not progressed as far as in can I, and on opening the gas was not so profuse. The general description there applied to the contents and to the nature of the subsequent plates is equally applicable in this instance.

See Culture 36, Class I.

Can V, Packer B.—Source and brand as Can I of this series. The extent to which the can had swelled, and the further description used above for Can IV apply here.

See Culture 37, Class I.

Can VI, Packer C.—Obtained direct from canning factory; packed in tomato sauce; characteristic "swelled" appearance top and bottom convex. On opening a small amount of gas escaped. The odour was not unpleasant, and may be described as the natural smell of normal sardines accentuated. The contents of the can were not nearly so much disintegrated as noted in some previously mentioned, were somewhat dry, and a little less hard than the contents of normal cans.

See Culture 64, Class I.

Swelled Cans, Series II, Packer A.

A cargo of sardines exported by packer A had been sunk in a harbour, remaining under water for six weeks. When the cargo was salvaged, a proportion of the cans were visibly swelled. The local Health Department submitted a number of these cans for examination, as a result of which the cargo was condemned. Such cans, of course, do not represent the "swelled cans" of commerce. As, however, their condition and the nature of their contents appeared somewhat similar to the swelled cans obtained from other sources, the characteristics of some of the organisms isolated have been included in this report.

To differentiate from the swelled cans obtained direct from the canning factories and from retailers I have designated the salvaged cans as "Swelled cans, series II." The brand of sardines of which this cargo consisted is one of the least expensive brands on the market; cottonseed oil is used.

Can II.—On shaking, perceptible "rattle" characteristic of the swollen cans. On opening with the cutter escape of gas and pronounced putrefactive odour; contents soft and disintegrated; colour dirty white with tendency to redness in inner portions.

See Culture 24, Class I; Culture 14, Class II.

Can III.—Characteristic "rattle"; escape of gas and pronounced putrefactive odour on opening of can; contents soft and disintegrated, and of a dirty white colour.

See Culture 26, Class I; Culture 16, Class II.

ORGANISMS OF THE GAS-PRODUCING TYPE.

Culture 24.

Source: Can II, Ser. II, Packer A.

Morphology.—Microscopically: coccus forms to short thick rods twice as long as broad; average length ·8—1 μ *Gram negative. From old agar cultures no evidence of spores.

Motility.—In hanging drop occurring singly, in twos and in chains; some individuals with rapid movement, some having slow undulating motion.

Cultural Characteristics.—

Agar slope.—36 hrs. 37° C.—growth luxuriant, raised, glistening, iridescent, yellowish-white by transmitted light.

Löeffler's Blood Serum.—24 hrs., 37 C. moderate, yellowish-white, no liquefaction.

Löeffler's Malachite Green Sol.—Green precipitate or weak coagulum at bottom of tube; this very slowly changes and within 14 days partially digested; liquid portion assuming brownish tint.

Gelatine Stab.—Room temperature; liquefaction begins in 24 hrs. crateriform; in three days liquefaction on surface and along track of needle, crateriform to infundibuliform; growth very slimy on this medium; in 7 days yellowish, cloudy stratiform extending 1 cm. from surface, remainder infundibuliform with heavy yellow flocculent sediment to bottom of tube. In 18 days liquefaction not yet complete; upper portion heavy milky even cloudiness, merging into layers of semi-transparent cloudiness, the lower portion a heavy ferric-yellow mass of precipitate.

Nutrient Broth.—24 hrs. 37°C.—heavy clouding with bluish rim; in 3 days flocculent flakes of bluish tint on sides of tube; in 5 days very heavy dense even clouding, watered silk appearance; this condition persists.

Herring Broth.—Condition similar to above; very heavy growth; in 9 days a loop of the liquid showing decided iridescent bluish sheen.

Milk.—In 24 hrs. unchanged, except that much froth on shaking; in 3 days coagulated, soft curd, some whey expressed; in 9 days yellow digested fluid 2/3 of tube, remainder white soft curd; in 14 days ropiness noted, and medium almost entirely digested with slight amount of flocculent curd at bottom of tube; in 5 weeks almost wholly turbid yellowish digested fluid with slight jelly-like yellowish iridescent flocculent curd on base of tube.

Litmus Milk.—In 24 hours much froth on shaking, violaceus for 1 cm. from surface, remainder paler; in 3 days partly coagulated soft curd, violaceus; in 9 days digestion proceeding, fluid yellowish; in 14 days blue rim at surface, medium 5/6 digested, reddish brown tint; in 5 weeks slight flocculence, curd at base of tube, remainder partially cleared and tinted dark purpureus to heliotrope.

Aesculin agar.—1 loop from peptone broth culture streaked on plates. In 24 hours growth but no definite black reaction; later assumes brown to black tint, moderate growth.

Aesculin broth.—In 24 hours black reaction.

MacConkey's N.R.B. Broth.—No reduction to canary yellow in 24 hours.

Gelatine colonies.—(1st appearance) room temperature, in 72 hours liquefaction well advanced; individual colonies up to 3 mm. diameter, round, saucer-shaped, entire edges; liquefaction typical of the proteus group, centre of colony dark white spot ·25 mm. diameter, remainder of colony varying from clear space to fine precipitated granules. Under the low power objective opaque centre, edges entire; medium tinted green, and distinct earthy smell.

Agar colonies.—20 hours at 37°C., growth moderate, surface colonies round, concave, glistening, raised, distinctly radiate; by transmitted light young colonies bluish, older colonies becoming whiter, more opaque and darker in centre. Sub-surface colonies small but well defined, white. Under low power objective surface colonies distinctly yellowish with entire edges; on focussing through, dense and dark; structure cannot be defined; smaller colonies dark centre, then pale yellow, and near the edges almost transparent. Sub-surface colonies well defined, edges entire, yellow to dense.

Temperature Relations:—

Thermal death point.—10 minutes' exposure in nutrient broth at 60°C.

Optimum temperature.—Cultures incubated at room temperature and at 37°C. grow well. Most satisfactory growth at 37°C.

Vitality on Culture Media.—The culture survives several months in artificial medium, agar or gelatine.

Relation to Oxygen.—The culture is a facultative anaerobe; incubated for 36 hours under anaerobic conditions moderate growth on glucose agar as discrete colonies along track of needle 1-2 mm. diameter; by transmitted light convex, dark white centres, paling to blue at edges. Growth is not so luxuriant as under aerobic conditions.

Biochemical Reactions:—

Indol production: Indol not produced.

Reduction of nitrates: Nitrates to nitrites.

Voges-Proskauer reaction: Positive.

Methyl red reaction: Alkaline.

Fermentation of Carbohydrates.—This culture does not rapidly ferment many of the carbohydrates. In 24 hours lactose is but feebly fermented to acid; saccharose, mannite and xylose are fermented to acid and gas with profuse frothing; arabinose and inulin give slight gas; while gas appears in glycerine

only after a period of 72 hours. The remaining substances used are fermented moderately well in 24 hours to acid and to gas.

Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.
+ +	+ −	+ +	+ +	+ −
Adonit.	Raffinose.	Arabinose.	Xylose.	Salicin.
− −	+ +	+ +	+ +	+ +
Aesculin.	Glycerine.	Inulin.		
+ +	+ +	+ +		

+ = acid.

++ = acid and gas.

Culture 26

Source: Can III, Ser. II, Packer A.

Morphology.—Microscopically, rods $1\frac{1}{3}$ to $1\frac{1}{2}$ times as long as broad; average length 1-6 μ with many longer forms even in young cultures. Gram negative*; from old agar cultures no evidence of spores.

Microscopic preparations made from cultures of this organism incubated at the same and at different temperatures have shown much variation in morphology; successive plate culturing, however, has failed to show impurity.

Motility.—In hanging drop occurring singly, and in twos, sometimes side by side; longer forms noted; non-motile.

Cultural Characteristics:—

Agar Slope.—36 hours, 37° C., moderate, along track of needle, glistening yellowish-white by transmitted light.

Löeffler's Blood Serum.—Growth slight after 72 hours. No liquefaction.

Löeffler's Malachite Green Solution.—24 hours, 37°C., coagulated as soft junket-like curd attached to sides and bottom of tube, green, with pale green liquid expressed. After 14 days no change.

Gelatine Stab.—Room temperature—in 3 days scant growth, filiform, no liquefaction; in 18 days no change apart from increased growth, no liquefaction.

Nutrient Broth.—24 hours, 37°C., moderate clouding, no pellicle, no sediment, no ring; in 3 days watered silk appearance; in 9 days no change except slight sediment at bottom of tube.

Herring Broth.—Similar to above, but much more luxuriant growth.

Milk.—In 24 hours at 37°C., no coagulation, much froth on shaking; in 3 days coagulation beginning; in 5 days firm coagulum, no gas, no digestion; in 16 days curd slightly split by gas. In 5 weeks shrinking of curd, but no digestion.

Litmus Milk.—In 24 hours violaceus, much froth on shaking, no coagulation; in 3 days liliaceous with weak coagulum; in 5 days curd slightly cracked by gas. In 5 weeks no digestion; pale lilac to isabella.

Aesculin agar.—One loop from peptone broth culture streaked on plates; no reaction.

Aesculin broth.—In 24 hours. Slight change but no black reaction; later medium darkened slowly in several days becoming black.

MacConkey's N.R.B. broth.—No reduction to canary yellow in 48 hours.

Gelatine Colonies.—(1st appearance), 72 hours at room temperature. Surface colonies yellowish white by transmitted light, $\frac{1}{2}$–$1\frac{1}{2}$ mm. diameter; a characteristic depression immediately around edge of colony could be seen on tilting the plate; no bluish appearance; no liquefaction. Under the low power objective colonies pale yellow, with paler rim, and entire edges, structure finely granular.

Agar colonies.—20 hours. 37°C. Growth slow, punctiform, scarcely visible to the eye. Examined 3 days; by transmitted light surface colonies greyish white, elliptical and round, the larger colonies 0·5 mm. diameter. Subsurface colonies similar to above; majority of the colonies immediately under the surface. Under the low power objective all colonies appeared dense, compact with edges entire to slightly serrated.

Temperature Relations:—

Thermal death point.—10 minutes exposure in nutrient broth at 60°C.

Optimum temperature.—On agar grows moderately well, room temperature and at 37°C.

Vitality on Culture Media.—The culture survives several months in artificial medium, agar or gelatine.

Relation to Oxygen.—Incubated for 36 hours under anaerobic conditions, scant growth on glucose agar, small gas bubbles in medium, clouding of condensation water. While growth is noted, the organism prefers aerobic conditions.

Biochemical reactions:—

Indol production: Indol not produced.
Reduction of nitrates: ?
Voges-Proskauer reaction: Negative.
Methyl red reaction: Slightly acid.

Fermentation of Carbohydrates.—The carbohydrates used are but feebly acted upon by this culture. In each case, however—with exception of inulin—those substances which are fermented to gas have shown the positive reaction within 24 hours at 37°C., and no further gas production has taken place even after 5 days. The Andrade indicator has changed to a clear scarlet and no reduction has taken place after prolonged incubation. The two substances most easily acted upon are glucose and saccharose.

Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.
+ +	+ +	+ +	+ +	+ −
Adonit.	Raffinose.	Arabinose.	Xylose.	Salicin.
− −	+ +	+ +	+ +	+ +
Aesculin.	Glycerine.	Inulin.		
+ +	+ −	+ ±		

+ = acid.
++ = acid and gas.

Culture 32.

Source:—Can. I. Ser. I. Packer B.

Morphology:—Microscopically short thick rods twice as long as broad; average length 1–6 μ staining unevenly with Kühne's methylene blue; some longer and thinner forms, but repeated replating has failed to show impurity. Gram negative*; from old agar cultures no evidence of spores.

Motility.—In hanging drop occurring singly and in twos, actively motile, progression as in semi-circles.

Cultural Characteristics:—

Agar Slope.—36 hours 37° C., luxuriant, raised, thick, along track of needle, glistening, iridescent, yellowish white transmitted light, medium slight tendency to brown.

Herring agar.—20 hours 32° C., growth abundant and heavy along track of needle, contoured, yellowish-white; spreading over slope as bluish film of discrete colonies, transmitted light, glistening, iridescent; heavy clouding condensation water.

Löeffler's Blood Serum.—24 hours 37° C., moderate, moist, spreading; no liquefaction after 7 days.

Löeffler's Malachite Green Sol.—Coagulated as soft junket like curd attached to sides and bottom of tube, green, gas bubbles, light green clear fluid expressed; after 14 days coagulum as precipitation on sides of tube, no reduction of colour.

Gelatine Stab.—Room temperature—24 hours filiform, no liquefaction; in 4 days growth abundant; in 1 week no liquefaction and no change in medium, growth equally good in stab and on surface; no liquefaction in 21 days.

Nutrient broth.—24 hours 37° C., moderate, clouding, slight pellicle easily dislodged, pale bluish rim at top, very slight tendency to flocculency; in 48 hours flocculent precipitate suspended and at bottom; in 7 days discrete particles adhering to tube at surface, even clouding, clotted sediment on shaking.

Herring broth.—Similar to above, but much heavier.

Milk.—18 hours, 37° C., much froth on shaking, no coagulation; in 72 hours coagulation beginning, frothy; in 4 days weak coagulum with whey expressed, gas bubbles, curd splitting, whey white cloudy; in 10 days condition accentuated, no liquefaction.

Litmus milk.—In 18 hours frothy, no coagulation, violaceus, merging into light violaceous near bottom of tube; in 48 hours liliaceous, frothy, no coagulation; in 72 hours still frothy, coagulation beginning; in 4 days coagulated, some whey expressed, curd split by gas holes; in 14 days bleached with red rim at top.

Aesculin agar.—1 loop from peptone broth culture streaked on plates. In 24 hours 37° C. growth brown-black reaction.

Aesculin broth.—In 24 hours, black reaction.

MacConkey's N.R.B. broth.—No reduction to canary yellow in 48 hours.

Gelatine colonies.—Room temperature (1st appearance). In 72 hours growth luxuriant and rapid; surface colonies up to ½—1 mm. diameter, white and glistening; depression around edge of colony, as if gelatine under tension—See Culture 26. Smaller colonies bluish to white, round; subsurface colonies small, bluish to bluish white. Under low power objective surface colonies dense, pale-yellow, with paler rim and entire edges, structure finely granular; subsurface colonies similar with homogenous structure, round, edges clearly defined and entire.

Agar colonies.—20 hours 37° C., growth rapid, abundant, surface colonies 1½—2 mm. diameter, concave, smooth, glistening, tendency to striate; by transmitted light ferric to yellowish-white centre, paling to blue tint at edges, smaller colonies bluish white; subsurface colonies up to ·5 mm. diameter, yellowish-white. Under low power objective surface colonies finely granular structure, ferric-yellow paling at edges, edges entire; subsurface colonies dark " mound " appearance in centre, remainder pale lemon, finely granular with tendency to grumose, edges entire.

Herring agar colonies.—Two to three times diameter of above, umbonate, radiate, concentrically ringed.

Temperature Regulations:—

Thermal death point.—Some variation has been exhibited and further tests require to be made; tests performed up to the present indicate the T.D.P. to be around 60° C., exposed for 10 minutes in nutrient broth.

Optimum temperature.—Cultures incubated at room temperature and at 37° C. grow well; most satisfactory growth at 37° C.

Vitality on culture media.—The culture survives several months on artificial medium, agar or gelatine.

Relation to Oxygen:—

The culture is a facultative anaerobe; incubated for 36 hours at 37° C. under anaerobic conditions moderate growth on slope of glucose agar; medium cracked and split by gas bubbles, much froth in tube and heavy clouding of condensation water. The organism appears to grow equally well in the presence or in the absence of oxygen.

Biochemical Reactions:—

Indol production: Indol not produced.
Reduction of nitrates: Nitrates reduced to nitrites.
Voges Proskauer reaction: Negative.
Methyl red reaction: Alkaline.

Fermentation of Carbohydrates.—The action of this culture on lactose is feeble and slow, gas not appearing until the second day; dulcite is but slightly fermented to acid and no gas is produced. Aesculin is fermented to acid and gas in 24 hours and in 9 days the Andrade indicator reduced to a lemon yellow turbid iridescent colour, while no reduction is noted in the case of salicin. All the other test substances are fermented to acid and to gas rapidly with profuse frothing and heavy turbidity within 24 hours.

Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.
+ +	+ +	+ +	+ +	+ −
Adonit.	Raffinose.	Arabinose.	Xylose.	Salicin.
− −	+ +	+ +	+ +	+ +
Aesculin.	Glycerin.	Inulin.		
+ +	+ +	+ +		

+ = acid.
++ = acid and gas.

Culture 34.

Source: Can. II., Ser. I., Packer A.

Morphology.—Microscopically varying from coccus forms to short rods; the majority 8–1 μ long and twice as long as broad, many thinner; stains unevenly with Kühne's methylene blue; Gram negative*; from old agar cultures no evidence of spores.

Motility.—In hanging drop occurring singly and in twos; actively motile.

Cultural Characteristics:—

Agar slope.—36 hours at 37° C., moderate along track of needle, glistening iridescent, bluish by transmitted light, gas bubbles in medium presumably due to fermentation of the muscle sugar in beef extract. In agar culture 2 months old distinct sliminess has been noted.

Herring agar.—20 hours 32 C., growth abundant, contoured, yellowish white growth along track of needle, spreading over slope as bluish film of discrete colonies; glistening, iridescent; heavy clouding of condensation water.

Löeffler's Blood Serum.—24 hours 37° C Moderate, ferric yellow growth, no liquefaction after 7 days.

Löeffler's Malachite Green Sol.—In 24 hours 37° C. coagulated as described in culture 32; in 14 days medium assuming a greenish brown tint, no definite reduction and no liquefaction.

Gelatine stab.—Room temperature –24 hours filiform, no liquefaction, equally good on surface and in stab; in 4 days growth abundant; in 7 days no liquefaction and no change in medium; no liquefaction in 21 days.

Nutrient broth.—18 hours 37° C., clouding moderate, slight pellicle; on shaking small flakes perceptible in medium; bluish rim; slight viscid sediment; in 72 hours cloudy waves, as watered silk, some flocculent precipitation in suspension.

Herring broth.—Similar to above, but heavier.

Milk.—18 hours 37° C., much froth on shaking, no coagulation; in 48 hours, weak coagulum beginning; in 72 hours coagulated with gas and expulsion of whey, curd later splitting with gas holes.

Litmus milk.—18 hours 37° C., much froth on shaking, liliaceous, no coagulation; in 48 hours weak coagulation beginning; in 72 hours coagulated, gas, whey expressed, later bleaching to isabella and much splitting of curd by gas.

NOTE.—Milks and litmus milks incubated for 2 months have appeared to be slowly digesting; up to the present I have been unable to verify this and further tests must be made to establish the final condition of the clot.

Aesculin agar.—1 loop from peptone broth culture streaked on plate. In 24 hours at 37° C., reaction brown-black.

Aesculin broth.—In 24 hours black reaction.

MacConkey's N. R. B. Broth.—In 48 hours, 37° C., slight reduction to eosin tint, but no final reduction to canary yellow.

Gelatine colonies.—Room temperature (1st appearance) surface colonies up to ½ mm. diam.; by transmitted light bluish-white, glistening, almost transparent, resembling more the description of the *B. typhosus* colonies than the typical *B. Coli* colony; flat; subsurface colonies smaller, white to yellow-white, depression around edges, see Culture 32. Under the low power objective surface colonies pale yellow, paling near rim with hedges entire; structure finely granular with clearly defined border around more dense central structure; subsurface colonies similar.

Agar colonies.—20 hours 37°C., growth moderate, not so rapid as other cultures; surface colonies 1 – 1½ mm. diameter, round, concave, glistening; by transmitted light bluish with pin-point dark white centre, distinctly radiate. Subsurface colonies dirty white; organism growing better just under surface. Under low power objective surface colonies dark centre, remainder of colony faintly discernible as finely granular lemon yellow, with edges entire; subsurface dark, compact, too dense for structure to be differentiated, edges entire.

Temperature Relations:—

Thermal death point.—10 minutes exposure in nutrient broth at 60°C.

Optimum temperature.—Cultures incubated at room temperature and at 37°C. grow well; most satisfactory growth at 37°C.

Vitality on Culture medium.—The culture survives several months on artificial medium, agar or gelatine.

Relation to Oxygen.—The culture is a facultative anaerobe; incubated for 36 hours at 37°C. under anaerobic conditions growth scant on slope as fine discrete colonies; heavy growth and clouding in condensation water. Slope broken and cracked by gas bubbles, these ½ cm. diameter and extending throughout the medium; much froth.

Biochemical Reactions:—

Indol production: Indol not produced.
Reduction of Nitrates: Nitrates reduced to nitrites.
Voges-Proskauer reactions: Negative.
Methyl red reaction: Alkaline.

Fermentation of Carbohydrates.—The culture has a characteristic action upon dulcite; this test substance being fermented profusely to gas in 48 hours; acid and some gas produced within 24 hours. In aesculin, gas appears within 48 hours. Inulin is fermented to gas only after 7 – 10 days incubation. The remaining test substances are fermented moderately well to acid and gas within 24 hours; but in no case on further incubation is the reaction profuse as in the fermentation of dulcite.

Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.
+ +	+ +	+ +	+ +	+ +
Adonit.	Raffinose.	Arabinose.	Xylose.	Salicin.
− −	+ +	+ +	+ +	+ +
Aesculin.	Glycerine.	Inulin.		
+ +	+ −	+ +		

+ = acid.
++ = acid and gas.

Culture 35.

Source: Can. III, Ser. I, Packer A.

Morphology: Microscopically large coccus forms to short thick rods; ·8 μ diam. to 1 μ long; stain evenly with Kühne's methylene blue; Gram negative*; from old agar cultures no evidence of spores.

Mobility: In hanging drop appearing singly and in twos; no motility.

Cultural characteristics:—

Agar Slope.—36 hours 37° C., moderate to abundant along track of needle, glistening, iridescent, porcelain white by transmitted light.

Herring Agar Slope.—20 hours 32° C., growth abundant, yellowish white along track of needle raised edges, glistening iridescent, by transmitted light the thinner parts bluish discrete colonies.

Löeffler's Blood Serum.—24 hours 37° C., luxuriant, moist; no liquefaction after 7 days.

Löeffler's Malachite Green Solution:—24 hours 37°C. Coagulated junket like coagulum clinging to sides of tube, gas; in 72 hours reduced greenish yellow; in 14 days reduced to yellowish-brown slimy looking liquid, partially digested.

Gelatine Stab.—Room temperature, in 24 hours filiform growth equally good surface and stab, no liquefaction, slight gas—presumably from muscle sugar—growth luxuriant. No liquefaction in 21 days.

Nutrient Broth.—18 hours 37° C., clouding even, no pellicle, no sediment, bluish rim at surface; in 48 hours heavy clouding, viscid sediment at bottom on shaking; in 72 hours flocculent suspension, later sediment increasing, medium becoming clearer, and flocculency.

Herring Broth.—Moderate clouding, bluish rim at surface, pellicle, viscid precipitate on shaking; in 4 days very heavy brown-black sediment, later flocculency and heavy clouding.

Milk.—In 18 hours at 37° C., frothy but no coagulation; in 72 hours coagulation commencing, gas; in 4 days gas holes in curd, frothy; in 10 days clear whey on surface of soft gassy curd. In 2 months no digestion.

Litmus Milk.—In 18 hours 37° lilaceus, much froth and gas, no coagulation; in 72 hours coagulation beginning; in 10 days tinted whey on surface of soft curd pinkish to isabella; no digestion in 2 months.

Aesculin agar.—37° C. One loop from peptone broth culture streaked on plates; in 24 hours reaction brown to black.

Aesculin broth.—37°C. Black reaction in 24 hours.

MacConkey's N.R.B. Broth.—37°. In 48 hours no reduction to canary yellow.

Gelatine Colonies.—(Room temperature) (1st appearance). Surface colonies up to ½ mm. diameter, bluish white to white, glistening, smaller colonies more distinctly blue; depression around colonies as noted Culture 32. Subsurface colonies yellowish white, small. Under low power objective the centre yellowish brown dense compact surrounded by pale border ⅓ diameter of colony; edges entire, clearly defined and hyaline. The differentiation of border from centre bears a close resemblance to colony of Asiatic cholera (plate 227 Kolle & Wassermann Atlas Tafel 10), and is not unlike plate 45 of colon colony (Park & Williams, Path. Micro-organisms, 5th edition, page 110). In the large surface colonies the whole structure is more homogeneous. Subsurface colonies appear similar.

Agar colonies.—20 hours 37° C., surface colonies 1½-2 mm. diameter. Flat to umbonate, growth rapid, colony round, surface smooth, glistening, iridescent. By transmitted light ferric-yellow centre paling to bluish at edge. Subsurface colonies punctiform. Under the low power objective surface colonies are dark in centre, "mound" appearance, gradually merging to pale lemon-brown colour, structure finely granular to grumose; subsurface colonies similar.

Temperature relations:—

Thermal Death Point.—10 minutes exposure in nutrient broth at 60°C.

Optimum Temperature.—Cultures incubated at room temperature and at 37°C. grow well; better growth at 37°C.

Vitality on Culture Media.—Survives several months, in artificial media, agar or gelatine.

Relation to oxygen.—Facultative anaerobe; incubated at 37°C. for 36 hours under anaerobic conditions, moderate bluish growth by transmitted light, on glucose agar; spreading over slope as bluish film, small discrete colonies with centre more opaque. Condensation water heavily clouded; much froth; medium throughout tube riddled with gas bubbles. The organism appears to grow equally well aerobically or anaerobically.

Biochemical Reactions:

Indol production: Indol not produced.
Production of nitrates: Nitrates reduced to nitrites.
Voges-Proskauer reaction: Positive.
Methyl red reaction: Alkaline.

Fermentation of Carbohydrates.—The action of the culture on dulcite is variable but it evidently is able to ferment this alcohol to gas, some tests being

positive, some negative; the alcohol adonit on the other hand is fermented to acid and profuse gas with frothing in 24 hours. The action on inulin is somewhat characteristic, fermentation to acid and gas with frothing in 24 hours; no other strain isolated has such pronounced effect on this test substance. Within 24 hours all the remaining carbohydrates are fermented to acid and profusely to gas with very pronounced frothing. In general this culture is much more active in its fermentation reactions than any of the cultures hitherto described.

Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.
+ +	+ +	+ +	+ +	+ ±
Adonit.	Raffinose.	Arabinose.	Xylose.	Salicin.
+ +	+ +	+ +	+ +	+ +
Aesculin.	Glycerine.	Inulin.		
+ +	+ +	+ +		

+ = acid.
++ = acid and gas.

Culture 36.

Source: Can IV. Ser. I. Packer B.

Morphology.—Microscopially varying from very short stumpy rods to forms twice as long as broad; the majority ·8–1 μ long, staining unevenly with Kühne's methylene blue; Gram negative*; from old agar culture no evidence of spores.

Motility.—In hanging drop occurring singly and in pairs; extremely active motility.

Cultural Characteristics:—

Agar slope.—36 hours 37°C., moderate along track of needle, glistening iridescent, Porcelain to yellowish white by transmitted light.

Herring Agar slope.—20 hours at 32°C., growth moderate, slightly raised, dry but glistening, some discrete colonies, by transmitted light blue to yellow.

Löeffler's Blood Serum.—24 hours 37° C., moderate, glistening. No liquefaction after 7 days.

Löeffler's Malachite Green Sol.—24 hours 37°C., coagulated as Culture 34, much gas; in 72 hours reduced to greenish yellow. In 14 days coagulum not further reduced but precipitation on sides and bottom of tube; ferric-yellow liquid expressed.

Gelatine stab.—Room temperature—in 24 hours filiform growth equally good on surface and in stab; in 48 hours no liquefaction growth on surface showing, moist; in 4 days growth luxuriant; in 7 days growth becoming brown, medium slightly tinted; no liquefaction arter 21 days.

Nutrient Broth.—18 hours 37°C., moderate even clouding, no pellicle, bluish rim at top, no sediment; in 48 hours heavy clouding watered silk appearance, later sediment noticeable; no pellicle even after 10 days.

Herring broth.—Moderate growth, clouding flocculent suspension, bluish rim, no pellicle; in 48 hours brown viscid sediment precipitated; in 10 days ring on surface, very heavy flocculent growth, black sediment.

Milk.—18 hours 37°C. Much gas on shaking, with froth persistent, no coagulation; in 14 days weak coagulum commencing and coagulation slowly completed when examined at the end of two months.

Litmus Milk.—In 18 hours no coagulation, much froth on shaking with froth persisting; violaceus merging into heliotrope; no further change in 10 days; in 14 days lilaceus, no coagulation; when examined 6 weeks late coagulation complete, lilaceus.

Aesculin agar.—One loop from peptone broth culture streaked on plates; in 24 hours 37° C. brown to black reaction.

Aesculin broth.—The typical black reaction not given after 7 days; change only to brown.

MacConkey's N.R.B. broth.—In 48 hours 37° C. an eosin tint but no reduction to canary yellow after 7 days.

Gelatine colonies.—Room temperature (1st appearance) in 72 hours surface colonies small, average ½ mm. diameter, glistening flat, round; by transmitted light bluish white, almost transparent; characteristic ring in gelatine as noted. Culture 32; surface colonies yellowish white, small, round. Under the low power objective surface colonies round distinctly granular and dark yellow centre, surrounded by pale border and edges entire and hyaline; on gelatine, the colonies unlike those previously described.

N.B.—On referring to the notes made when this culture was originally isolated six months ago, I find that on agar the colonies were characteristically different from the colonies of Cultures 32, 34 or 35. It is of interest to note that this individuality has been maintained throughout a period of this length, and in spite of having many times been subcultured on laboratory media.

Agar Colonies.—20 hours, 37°C. growth rapid; surface colonies 1-1½ mm. diameter; flat, glistening, iridescent; some colonies extending as thin blue protuberances over the medium; by transmitted light colonies bluish, little darker and more opaque in centre. Subsurface colonies up to ·25 mm. diameter. Under the low power objective surface colonies coarsely granular, immediate centre slightly darker and well defined; remainder same structure throughout; edges entire; subsurface colonies compact, grumose to "mound-like" structure; often the surrounding medium a light ferric colour due to precipitated granules with no definite outline.

Temperature Relations:—

Thermal Death Point.—10 minutes exposure to 60° C. in nutrient broth.

Optimum Temperature.—Growth satisfactory when incubated either at room temperature or at 37°C. Most satisfactory growth at 37°C.

Vitality on Culture Media.—The culture survives several months on artificial media, agar or gelatine.

Relation to Oxygen:—Facultative anaerobe; inculated for 36 hours at 37° C. under anaerobic conditions grows on glucose agar as pale bluish thin film along track of needle, transmitted light; spreading over slope as discrete colonies; heavy cloudy growth in condensation water; much froth in tube, gas bubbles ½ cm. diameter throughout medium. The organism grows equally well aerobically or anaerobically.

Biochemical Reactions:

Indol production	Indol not produced.
Reduction of nitrates	Nitrates reduced to nitrites.
Voges-Proskauer reaction	Positive.
Methyl red reaction	Alkaline.

Fermentation of Carbohydrates: The culture ferments lactose to acid, but gas is not produced until 72 hours after inoculation; the amount then is small and no increase is observed on further incubation; glucose, saccharose, xylose, arabinose, and mannite are fermented to acid with profuse evolution of gas within 24 hours. The action upon raffinose is feeble. The Andrade indicator

is rapidly decolourized in the aesculin, assuming a lemon yellow tint, such persisting; this colour is partially due to the glucoside itself.

Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.
+ +	+ +	+ +	+ +	– –
Adonite.	Raffinose.	Arabinose.	Xylose.	Salicin.
– –	+ –	+ +	+ +	– –
Aesculin.	Glycerine.	Inulin.		
+ – –	+ –	+ –		

+ = acid.
+ + = acid and gas,

Culture 37.

Source: Can V. Ser. I. Packer B.

Morphology.—Microscopically rods, three times as long as broad; average length 1·6 μ. Stain evenly. Gram negative*; from old agar cultures no evidence of spores.

Motility.—In hanging drop occurring singly and in twos; motile; movement varying from revolving motion to a wavelike undulating motion.

Cultural Characteristics:—

Agar slope.—36 hours, 37° C., luxuriant along track of needle, raised, glistening, iridescent, yellowish-white by transmitted light; gas bubbles in medium presumably from muscle sugar in meat extract. At times, particularly in the older cultures, agar growth decidedly slimy, drawing out on the needle. In 7 days, medium lemon to brown.

Herring agar.—20 hours at 32°C. Along track of needle heavy, raised, compact, greyish white, glistening, spreading as thick blue-green veil, by transmitted light slightly iridescent, heavy clouding of condensation water.

Löeffler's Blood Serum.—24 hours, 37° C., luxuriant, raised, white, spreading, no liquefaction in 7 days.

Löeffler's Malachite Green Sol.—In 24 hours precipitated light green coagulum on sides of tube; in 48 hours reduction to yellow beginning in 7 days reduced to yellow and almost entirely digested.

Gelatine Stab.—Room temperature—in 24 hours liquefaction commencing; in 48 hours crateriform to extent of 3mm, continuing down the stab as infundibuliform; in 7 days liquefaction complete and medium sharply divided into layers; immediately below surface liquefaction appears the colour of turbid whey, in successive layers turbidity and cloudiness gradually disappearing; heavy yellow flaky precipitate at bottom.

Nutrient Broth.—18 hours, 37°C., heavy clouding, surface iridescent, pellicle, bluish rim easily detached on shaking—life-belt form—medium slightly flocculent; in 4 days clouding very heavy, bluish rim; later sediment.

Herring Broth.—Very similar to above but heavier growth; in 4 days heavy clouding and thick bluish white pellicle; later flocculent.

Milk.—18 hours, coagulation commencing; in 48 hours coagulated with gas and digestion well advanced; in 10 days more than half digested, whey yellowish, heavy pellicle, soft curd; in 14 days gas bubbles still persisting, digestion proceeded, ¾ tube, the soft curd adhering to the glass, digestion not proceeding directly from surface to bottom. At a later date when the organism had

been in pure culture for several months, a decided ropiness was noted, milk tubes being distinctly slimy within 24 hours after inoculation. This feature appears to have developed under cultivation and has since persisted.

Litmus Milk.—In 18 hours violaceus, no coagulation; in 48 hours gas, heavy pellicle, coagulated and digestion proceeding; in 4 days a yellow digested fluid extending 2cm. below surface, remainder violaceous; in 10 days ½ digested, remainder soft gelatinous curd; in 14 days except for tint, appearance very similar to milk as noted above.

Aesculin agar.—1 loop from peptone broth culture streaked on plates. In 24 hours black reaction.

MacConkey's N.R.B. Broth.—In 24 hours heavy growth. No reduction to canary yellow. Later colour slightly changed but no definite reduction.

Gelatine Colonies.—(1st appearance.) Room temperature in 72 hours liquefaction well advanced; individual colonies up to 3mm. diameter, round, saucer-shaped, characteristic of the organisms of the proteus group; centre of colony dark white spot ·25 mm. diameter, then clear space, then semi-transparent rim. Under the low power objective opaque centre merging into myceloid filaments, then clear space, and heavily clouded borders with entire edges; medium unchanged, no characteristic smell.

Agar colonies.—20 hours at 37°C. growth rapid, surface colonies concave, 1½-2½mm. diameter; very slimy after repeated sub-culturing drawing out on needle 10-15cm.; glistening; by transmitted light distinctly radiate, whole colony bluish but slightly more opaque in centre; subsurface colonies bluish to white. Under the low power objective surface colonies brownish with dark opaque centre in some, finely to coarsely granular; some colonies same structure throughout; edges entire hyaline. Subsurface colonies distinct, grumose to mound like.

Temperature Relations:—

Thermal death point.—10 minutes exposure in nutrient broth at 60°C.

Optimum temperature.—Cultures incubated at room temperature and at 37°C. grow well. Most satisfactory growth at 37°C.

Vitality on Culture Media.—The culture survives several months in artificial medium agar or gelatine.

Relation to Oxygen.—The culture is a facultative anaerobe; incubated for 36 hours under anaerobic conditions moderate growth on glucose agar slope, bluish tint; very heavy clouding of condensation water; on the slope seen as discrete colonies varying from a thin bluish film to converse moist colonies 1 mm. diameter with ferric yellow centre paling towards edges. The medium riddled with gas bubbles ½ - 1 cm. diameter, much froth in tube. This organism appears to grow equally well aerobically or anaerobically.

Biochemical Reactions:—

Indol production: Indol produced.

Reduction of Nitrates: Nitrates reduced to nitrites.

Voges-Proskauer reaction: Positive.

Methyl red reaction: Alkaline.

Fermentation of Carbohydrates.—This culture ferments lactose feebly to acid, the Andrade indicator showing reduction in 48 hours, and no gas is produced. Raffinose, glycerine and inulin are fermented to acid with slight production of gas; the gas in glycerine not appearing until the second day. The remaining fermentable substances are acted upon rapidly, evolving gas profusely within

24 hours. It will be seen that of the two glucosides used, salicin and aesculin, the former only is fermented to gas.

In the later cultural experiments a distinct sliminess appeared in all tubes, in peptone broths with and without added sugars; a pale white rim at surface observed to be slimy after several days at 37°C.

Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.
+ +	+ −	+ +	+ +	− −
Adonit.	Raffinose.	Arabinose.	Xylose.	Salicin.
− −	+ +	+ +	+ +	+ +
Aesculin.	Glycerine.	Inulin.		
− +	+ +	+ +		

+ = acid.

++ = acid and gas.

Culture 64.

Source Can. VI., Ser. I, Packer C.

From this source four strains have been isolated—64, 64a, 64b aerobically, and 64c anaerobically. The similarity of the strains in culture is such that a detailed description of each is not warranted. There are, however, certain cultural differences in 64a, 64b and 64c as compared with 64, which I have thought worthy of special mention; and these have been noted in the following description:—

Morphology.—Microscopically varying from coccus forms to short thick rods; the former ·8 μ diameter, the latter $1\frac{1}{2}$ times as long as broad; Gram negative.* The culture has been recently isolated, and no evidence of spores has been obtained; this feature cannot at present be finally reported upon.

Motility.—In hanging drop occurring singly and in twos; very actively motile; meteoric flashing across the field.

Cultural Characteristics:—

Agar Slope.—24 hours, 37°C., moderate along track of needle, flat, slightly contoured, edges well defined, iridescent, by transmitted light yellowish white with bluish edges.

Löeffler's Blood Serum.—Moderate, no liquefaction; in 72 hours moderate, much less than culture 65.

Löeffler's Malachite Green Sol.—24 hours 37° C., precipitate at bottom of tube, no coagulum, liquid turbid, pea green colour; in 7 days yellowish brown turbid fluid with ferric precipitate at bottom.

Gelatine Stab.—Room temperature—24 hours, filiform, no liquefaction; in 7 days no liquefaction, growth luxuriant, surface and in stab; yellow growth in stab.

Nutrient Broth.—24 hours 37° C., even clouding abundant, 'watered silk" appearance, no pellicle, no sediment; in 7 days clouding even, no pellicle, heavy viscid yellowish white sediment at bottom of tube.

Milk.—24 hours 37°C., frothy on shaking, no coagulation; in 72 hours soft coagulum, much gas, whey expressed, curd shrinking; in 7 days white turbid whey, curd shrinking and split by gas.

Litmus milk.—In 24 hours liliaceous, much froth on shaking, no coagulation; in 72 hours soft coagulum, bleached to isabella, curd perceptibly shrinking; much gas; in 7 days completely bleached with heliotrope rim at surface, depth of 2 cm. turbid tinted whey, curd rapidly disintegrating and permeated with gas holes.

N.B.—This culture is violent in its action upon milk.

Aesculin agar.—1 loop peptone broth culture streaked on plates. In 24 hours 37°C., black reaction.

Aesculin broth.—In 24 hours, 37°C., black reaction.

MacConkey's N.R.B. Broth.—In 48 hours, 37°C., reduced to canary yellow.

Gelatine Colonies.—Room temperature (1st appearance)—identical with Culture 35—64a presents some variation. In 72 hours growth rapid abundant, more luxuriant than any of foregoing cultures; surface colonies up to 1 mm. diameter, compact, white, opaque with tendency to capitate, round; the smaller colonies bluish to bluish white. Subsurface colonies small compact.

Under the low power objective surface colonies have appearance identical with the literature descriptions of the *B. coli* colony, edges entire centre dark and opaque; subsurface colonies pale yellow in colour, very finely granular, slightly darker in centre. See Culture 35.

Agar Colonies.—20 hours, 37°C., growth rapid, flat, surface colonies 1½-2½ mm. diameter, round with tendency to spread; by transmitted light distinct bluish appearance, glistening, iridescent. Subsurface colonies up to 0·25 mm. diameter bluish to white. Under the low power objective surface colonies have small well defined dark centre, remainder lemon coloured; structure coarsely granular to grumose, edges entire, hyaline and well defined; pale radiate filaments—star-like rays—emanate from the colonies into surrounding medium. Subsurface colonies dark grumose to "mound-like."

Agar Colonies 64a.—20 hours 37°C., growth rapid, surface colonies bluish from 1–2 mm. diameter, glistening, iridescent, tendency to run together, forming blue film over agar. Subsurface colonies up to 1 mm. diameter white to yellowish white; some force their way to surface and appear as yellowish-white in centre, spreading on surface to 3 mm. diameter, blue, flat, concentrically ringed, contoured, edges undulate to lobate. Under the low power objective surface colonies (majority) finely granular at centre to grumose near edge; in some instances characteristic protuberances over agar as in culture 64, edges entire; subsurface lemon yellow, edges entire.

Temperature Relations:—

Thermal Death Point.—Exposed in nutrient broth for 10 minutes at 60°C. organism survives; exposed for 10 minutes at 70°C. no subsequent growth; exact temperature not yet definitely determined.

Optimum Temperature.—Grows well at room temperature and at 37°C. More satisfactory growth at 37°C.

Vitality on Culture Media.—Not yet determined.

Relation to Oxygen:—The culture is a facultative anaerobe; incubated for 36 hours under anaerobic conditions at 37 C. the medium—glucose sugar—is split, riddled with gas bubbles and upper portions blown to top of tube, much froth; heavy cloudy condensation water permeated whole medium. The organism grows with extreme rapidity both aerobically and anaerobically.

Chemical Reactions:

Indol production: Indol not produced.
Reduction of nitrates: Nitrates reduced to nitrites.
Voges-Proskauer reactions: Positive.
Methyl red reaction: Alkaline.

Fermentation of Carbohydrates.—The culture fails to ferment dulcite and adonit to acid or gas. All other test substances used are fermented within 24 hours

to acid, and profusely with much frothing to gas. In the glucose, lactose, saccharose, mannite, raffinose, and arabinose tubes the Andrade indicator is completely reduced within 24 hours, the reduction in the xylose, salicin and aesculin tubes being slower. Compared with the other cultures described herein, the rapid and violent action upon the carbohydrates is both distinctive and characteristic, as also is the rapidity with which the Andrade indicator is decolourized. The decolourized tubes when tested with methyl red show decided alkalinity. The rapid reversion to an alkaline reaction is a point of considerable interest.

64a.—The fermentation reactions are identical with those of the above culture, but a striking difference, which may be but temporary however, has been noted in the action upon the Andrade indicator. No reduction of the indicator in any tubes was noted within 24 hours; in 72 hours glucose, mannite, arabinose, xylose and salicin had changed from the scarlet tint of the acid reaction to a deep pink shade. In 7 days the glucose, arabinose, and xylose tubes only were completely reduced giving an alkaline reaction to methyl red.

I have as yet no explanation to offer regarding this apparent selective action towards the Andrade indicator; the inoculations were made at the same time, the same amount of the respective peptone broth cultures being added as the inoculum, such broth cultures being the same age, and all medium used of the same standard stock.

In this connection it may be of interest to mention that for some months I have been experimenting with Congo red as an indicator in connection with routine water analyses for the colon group; these experiments are as yet not sufficiently complete for publication; I have used this indicator in sugar broths as a confirmatory test and find that the strains 64 and 64a exhibit again, as in the Andrade indicator, a selective action.

Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.
+ +	+ +	+ +	+ +	– –
Adonit.	Raffinose.	Arabinose.	Xylose.	Salicin.
– –	+ +	+ +	+ +	+ +
Aesculin.	Glycerine.	Inulin.		
+ +	+ ±	+ +		

++ = acid and gas.
+ = acid.

Gas-Producing Orangisms, Summary, Morphological and Biological Features.

Culture.	Morphology.	Gram's Stain.	Spores.	Motility.	Agar Slope.	Blood Serum.	Malachite Green Sol.	Gelatine Stab.	Nutrient Broth.	Milk.	Aesculin Agar.	MacConkey's N.R.B. Broth.	Thermal Death pt.	Optimum Temperature.	Relation to Oxygen.	Source.
24	Coc. to Rod	–	–	+	Lux.	Mod. no Liq.	Coag. part. dig.	Liq.	Cloud. heavy	[a] Coag. 72 hrs. dig.	Brown Black	No reduction.	C. 60°	C. 37°	facul. anaer. prefers aerob.	Can II, Ser. II. Packer A.
[b] 37	Rod	–	–	+ Wave-like	Lux.	Lux. no Liq.	Reduced.	Liq.	Cloud heavy pell.	Coag. 18 hrs. dig. slimy.	Black	Slight reduction.	60°	37°	facul. anaer.	Can V, Ser, I, Packer B.
32	Rod	–	–	[c] + Act.	Lux.	Mod. no Liq.	Coag. no reduc.	No liq.	Mod. cldg. pell.	Coag. 72 hrs.	Brown Black	No reduction.	[d] 60°	37°	fac. anaer.	Can. I, Ser. I, Packer B.
36	Rod	–	–	+ Act.	Mod.	Mod. no Liq.	Coag. sligh. reduc.	No liq.	Mod, no pell.	Coag. 14 days.	Brown Black	No reduction.	60°	37°	fac. anaer.	Can. IV, Ser. I, Packer B.
26	Rod	–	–	....	Mod.	Slt. no Liq.	Coag. no reduction.	No liq.	Mod. cloud.	Coag. 72 hrs.	[e] No reaction.	No reduction.	60°	37° & 21°	facul. anaer. prefers aerobic	Can III, Ser. II, Packer A.
34	Coc. to Rod	–	–	+ Act.	Mod.	Mod. no Liq.	Coag. not reduced.	No liq.	Mod. cloud.	Coag. 48 hrs.	Black	No reduction.	60°	37°	facul. anaer.	Can II, Ser. I, Packer A.
35	Coc. to Rod	–	–	....	Mod. to Lux.	Lux. no Liq.	Coag. reduction.	No liq.	Even cloud. no pel.	Coag. 72 hrs. no dig.	Brown to Black	No reduction.	60°	37°	facul. anaer.	Can III, Ser. I, Packer A.
64	Coc. to Rod	–	–	+ Very act.	Mod.	Mod. no Liq.	Precip. reduction.	No liq.	Abun. cloud.	Coag. 72 hrs.	Black	Reduced to canary yellow.	[f] 60° to 70°	37°	facul. anaer.	Can VI, Ser. I, Packer C.

a Sliminess noted as digestion proceeds. b Sliminess appearing after successive subculturing. c Motion as in semi circles. d See page 197. e Aesculin fermented to gas, but no action on aesculin agar. f Not yet definitely determined, see page 206.

GAS-PRODUCING Organisms Summary, Biochemical Reactions.

Culture.	Indol.	Nitrate Reduction.	Voges Proskauer.	Methyl Red.	Glucose.	Lactose.	Saccharose.	Mannite.	Dulcite.	Adonite.	Raffinose.	Arabinose.	Xylose.	Salicin.	Aesculin.	Glycerine.	Inulin.	Source.
24	−	+	·	Alk.	++	+−	++	++	+−	−−	++	++	++	++	++	++[g]	++	Can II. Ser. II. Packer A.
37	h +	+	+	Alk.	++	+−	++	++	−−	−−	+·	++	++	++[i]	+−	++	++	Can V. Ser. I. Packer B.
32	−	+	−	Alk.	++	++[k]	++	++	+−	−−	++	++	++	++	++[h]	++	++	Can I. Ser. I. Packer B.
36	−	+	+	Alk.	++	++[m]	++	++	−−	−−	+−	++	++	−−	+ o −−	+−	+−	Can IV. Ser. I. Packer B.
P 26	−	?	−	Acid.	++	++	++	++	+−	−−	++	++	++	++	++[e]	+−	+ +−	Can III. Ser. II. Packer B.
34	−	+	−	Alk.	++	++	++	++	++[q]	−−	++	++	++	++	++	+−	++[r]	Can III. Ser. I. Packer A.
S 35	−	+	+	Alk.	++	++	++	++	+ +−	++	++	++	++	++	++	++	++[t]	Can III. Ser. I. Packer A.
X 64	−	+	+	Alk.	++	++	++	++	−−	−−	++	++	++	++	++	+ +−	++	Can VI. Ser. I. Packer C.

+ Acid. ++ Acid and Gas. g Gas after 72 hours. h Sliminess appearing after successive subculturing. i Note production of gas in one glucoside, not in the other. k Feebly to gas. l Reduced, lemon yellow. m Gas not produced until 72 hours. o Andrade indicator rapidly decolourised. p Carbohydrates feebly acted upon, but positive within 24 hours. q Characteristically profuse. r Reaction very slow. s Pronounced and rapid action upon carbohydrates. t Action on inulin pronounced, more so than any of the series. x The carbohydrates attacked are fermented profusely to gas within 24 hours; rapid reduction of Andrade indicator and characteristically rapid reversion to alkalinity.

EXPERIMENTAL SWELLED CANS.

Having isolated strains of gas-producing bacteria from swelled cans of sardines, and having determined their cultural features and biochemical reactions, the next step was to attempt the experimental swelling of normal cans by inoculation of organisms already isolated. Up to the present I have used three cultures for this purpose—cultures 35, 37 and 64. These three cultures on the basis of their biological and biochemical reactions are sufficiently differentiated (pages 199-207) to warrant individual trials. A number of normal cans of sardines were most courteously supplied by the manager of the Chamcook factory, St. Andrews, N.B. Some of the cans were of sardines packed in cottonseed oil, olive oil having been used for the remainder. The cans had to be "punched," inoculated, and again sealed. In order to eliminate as far as possible any error of manipulation I obtained by courtesy of the chief engineer, the services of the college plumber, who undertook the soldering. To avoid trouble from escaping oil, the cans were placed on end, rather than flat on the bottom. By the usual method a layer of solder was first spread over a portion of the can; this I cleaned and sterilized with absolute alcohol, and then with a sterile awl punched a hole 3 mm. diameter. From a 1cc. pipette, 2 to 3 drops of a young peptone broth culture of the desired organism were quickly dropped in; a small square of sterilized tin heated in the flame was at once placed over the hole, and the soldering process performed. The layer of solder previously spread over the can assisted materially in making the process effective. In this manner cans were inoculated with the respective cultures; the control cans receiving exactly the same treatment minus the inoculation. The cans, each placed in the half of a large petri dish, were incubated at a temperature of 30° to 33° C. They were examined at frequent intervals, and in 4 days swelling was observed in those inoculated. In 7 days the swelling has become so pronounced that there appeared to be danger from explosions. The cans were examined.

Normal Cans.—(Punched and resoldered). These appeared perfectly normal; no oil in petri dish, no moisture on outside of can, no swelling, no "rattle" on shaking. When opened there was no escape of gas; contents firm in texture, flesh the white of the normal sardines, and comparatively dry; odour typical and mild; normal in every respect.

INOCULATED CANS.

Can 35.—Inoculated with culture 35, oil in petri dish and on surface of can; pronounced swelling, top and bottom of can, convex; on shaking, the typical "rattle" of the original "swells"; when opened escape of gas and exuding of oil. The contents were soft, moist, and disintegrated to an even greater degree than in many of the original "swells." The oil was intermixed with the macerated sardines, and gas bubbles were very evident throughout the whole. The colour was a little darker than normal. The odour was not putrefactive, but an accentuation of the typical normal swell. The conditions noted were as evident on the side immediately opposite the point of inoculation, as at the point of inoculation itself. The condition of this can and its contents was in every respect identical with the conditions found when examining the original typical "swells," but accentuated.

Can 37.—Inoculated with culture 37. The description given of can 35 is here strictly applicable; no variation could be noted.

Can 64.—Inoculated with culture 64. The swelling of this can was more pronounced, otherwise the description given of can 35 is here strictly applicable in every respect.

Isolation of Organisms.—Pieces of fish were taken from the respective cans and inoculated into series of liquid media; glucose peptone broth, peptone broth, and nutrient broth respectively. These tubes were incubated at 37°C. for 24 hours.

Pronounced clouding of the media by each inoculum was by that time evident. Plates were made on glucose agar, and after incubation at 37°C. for 24 hours, typical colonies were picked off and streaked on agar slopes. Subsequently series of inoculations were made, and the organisms isolated proved to be identical respectively with the strains with which the experimental cans were inoculated.

Cultures 35, 37 and 64 respectively have experimentally produced typical swelled cans, have been re-isolated and proved culturally identical with the original strain. The "Postulates of Koch" have been satisfied.

ORGANISMS WHICH DO NOT PRODUCE GAS.

Culture 7.

Source: Herring Excreta.

Morphology:—Spore forming rods, occurring singly, in twos and in long forms. Gram negative.

Cultural Characteristics:—

Nutrient broth.—In 24 hours at 37°C., membranous pellicle, medium clear; 1 month yellow sediment, medium clear.

Milk.—In 5 days pellicle, no change; in 1 month yellow turbid digestion extending $\frac{2}{3}$ down tube.

Litmus Milk.—In 24 hours no change; in 10 days pellicle, sediment, digestion with colour varying from yellow to dark purple.

Gelatine Stab.—Room temperature, liquefaction beginning in 2 days. In 5 days napiform to a depth of 5 mm., remainder filiform; in 14 days liquefaction still proceeding with lower part of stab a discrete villous growth; medium ferric lemon.

Biochemical Reactions:—

Indol: not produced.
Nitrates: not reduced.
Glucose broth: acid, even clouding, no gas.

This culture in its reactions is typical of many strains isolated from herring excreta.

Culture 21.

Source: Normal Can sardines, Packer A.

Morphology.—Extremely long thin rods, forming spores; in hanging drop occurring singly and in twos, motile, Gram positive.

Cultural Characteristics:—

Nutrient broth.—In 24 hours at 37°C., slight clouding, no pellicle; in three days membranous cup-shaped pellicle, medium cloudy; later, pellicle luxuriant, thick creamy, medium yellowish brown.

Milk.—No change up to 5 days, when weak coagulum beginning; in 9 days tubes half cogulated; in 16 days yellow digestion nearly complete, remainder of medium firm hard curd.

Litmus Milk.—No change in 24 hours; in 3 days pellicle, upper layers of milk dark purple, remainder violaceus, no coagulation; in 9 days digested without previous coagulation to muddy looking yellowish brown liquid.

Löeffler's Blood Serum:—Rapid liquefaction.

Gelatine Stab:—Room temperature, in 24 hours crateriform liquefaction beginning; proceeding slowly in 7 days to 5 cm. from surface of stab; in 18 days not complete, layers of yellowish precipitate.

Biochemical Reactions:—

Indol: not produced.
Nitrates: not reduced.
Glucose broth: acid, chiefly at surface, no gas.

From the same can, and other normal cans, strains were isolated which according to the reactions noted proved to be identical with this culture.

Culture 13.

Source: Swelled Can I, Series II, Packer A.

Morphology.—Large coccus, occurring as staphylococcus, no spores, Gram positive.

Cultural Characteristics:—

Nutrient broth.—24 hours at 37°C., moderate, cloudy; no pellicle.

Milk.—In 5 days no change; no change in 1 month.

Litmus milk.—As milk.

Gelatine Stab.—Room temperature. In 2 days no liquefaction; in 5 days scant growth filiform to discrete; in 14 days medium faintly browned, growth in stab discrete and ferric yellow tint; no liquefaction, growth better under surface.

Biochemical Reactions:—

Indol: not produced.
Nitrates: ?
Glucose broth: Acid, even clouding, no gas.

Culture 28.

Source: Same Can as Culture 13.

Morphology.—Long rods many times longer than broad, oval spores formed; Gram negative; in hanging drop appear singly; in twos and in long chains; motile with gliding movement.

Cultural Characteristics:—

Nutrient Broth.—24 hours 37° C. Moderate, cloudy, slight pellicle; in 1 month cloudy with flocculent yellow sediment.

Milk.—In 5 days no change; in 1 month digested completely, yellow turbid fluid.

Litmus Milk.—In 10 days dark purple fluid with no previous coagulation; unchanged in 1 month.

Löeffler's Blood Serum.—Rapid liquefaction.

Gelatine Stab.—Room temperature, in 2 days slight liquefaction noted; in 5 days liquefaction progressed to depth of 2 mm., stratiform, remainder of stab discrete colonies; in 14 days liquefaction 1 cm. depth, stratiform yellowish layers.

Biochemical reactions:—

Indol: not produced.
Nitrates: not reduced.
Glucose broth: Acid, upper part, pellicle, no gas.

Cultures 13 and 28 typical of several strains isolated from such cans.

Culture 14.

Source: Swelled Can II, Series II, Packer A.

Morphology: Long rods many times longer than broad; spores. Gram positive; in hanging drop occurring singly, in twos, and in chains; appear at first immobile but prolonged examination reveals slow laboured movement, some individuals appearing to push themselves along.

Cultural Characteristics:—

Nutrient broth.—24 hours 37°C., cloudy, flocculent pellicle; in 10 days heavy clouding with some flocculency; in 1 month clouding and yellow precipitate at bottom of tube.

Milk.—In 5 days no coagulation, ring, pellicle; in 1 month coagulated, some yellow whey expressed.

Litmus milk.—In 24 hours no change; in 10 days lilac, no coagulation; in 1 month coagulation, and some whey expressed.

Gelatine Stab.—Room temperature—in 2 days moderate growth, dip in gelatine; in 5 days crateriform liquefaction and spreading growth on surface of stab; in 14 days liquefection varied from V-shaped to crateriform to depth of 1 cm., cloudy; remainder of stab discrete.

Biochemical reactions:—

Indol: not produced.
Nitrates: not reduced.
Glucose broth: acid, more particularly near the surface, no gas.

Culture.	Morphology.	Spore formation.	Motility.	Gram's stain.	Nutrient broth.	Milk.	Litmus milk.	Löeffler's blood serum.	Gelatine stab.	Indol.	Reduction of nitrates.	Glucose broth.	Source.
7	Rod.	+	?	–	Pellicle, med. clear.	Slow digest.	Digest.	... ...	Liquef.	—	—	+ –	Herring excreta.
21	Rod.	+	+	+	Clouding, later pellicle.	Slow coag. later dig.	Digest. slowly without previous coagln.	Rapid liquef.	Liquef. slow.	–		+ –	Sardines, Packer A, Normal can.
13	Coccus.	—	?	+	Moder. cloudy.	No change.	No change.	... ...	No liquef.	—	?	+ –	Swelled Can I, Ser. II, Packer A.
28	Rod.	-	+	—	Cloudy, later pellicle.	Slow digest.	Cleared with no coag.	Rapid liquef.	Liquef. slowly.	–	—	+ —	As Culture 13
14	Rod.	+	+ feeb	+	Cloudy.	No change.	Slow digest.	. . . . .	Liquef. after 14 days.	—	—	+ —	Swelled Can II (Ser. II) Packer A.
16	Coccus.	—	—	+	Cloudy, later precip.	Coag. slow.	Coag. slow.	....	Liquef. slowly.	—	—	+ —	Swelled Can III (Ser. II) Packer A.

BRIEF SUMMARY.

1. Forty cans of sardines, "swelled," and "normal," have been submitted to a bacteriological examination.

2. Cottonseed oil, and the excreta of fresh herrings have been examined.

3. From the "swelled" cans eight strains of gas-producing bacteria have been isolated,—Cultures 24, 26, 32, 34, 35, 36, 37 and 64.

4. The eight strains have been studied morphologically, biologically, and biochemically, and have been described, pages 192-207.

(*a*) Two strains, Cultures 24 and 37, liquefy gelatine, and fail to ferment lactose; these are tentatively placed in the *Proteus* group, *B. vulgaris* (Hauser 1885), Migula 1900.

(*b*) The remaining six strains are lactose-fermenting types. I consider that these include typical and a-typical types of the *colon-aerogenes* group (Escherich); but for the present an individual classification is not offered.

5. The features and reactions of the gas-producing bacteria have been summarized; pages 208 and 209.

6. Experimental "swellings", typical in every respect have been produced in the laboratory on inoculation with Cultures 35, 37, and 64 respectively. The organisms subsequently isolated have been proved culturally to be identical with those used for inoculation; thus satisfying the "Postulates of Koch."

7. No bacteria have been found in the cottonseed oil.

8. Non-gas-producing bacteria have been isolated from herring excreta, from swelled cans, and from a small percentage of the normal cans examined; brief notes are presented on pages 211-213.

9. No gas producing bacteria have been isolated from normal cans of sardines.

I desire to express my indebtedness to Dr. A. B. Macallum; to Dr. A. G. Huntsman; to Dr. F. C. Harrison; to the Maine Inspectors of the "National Canners' Association of America"; and to the proprietors and managers of the various canning factories which were visited with their permission.

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XIII.

BACTERIAL DESTRUCTION OF COPEPODS OCCURRING IN MARINE PLANKTON.

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During the summer of 1916 I was investigating the bacteriological content of "Swelled Canned Fish" for the Biological Board of Canada at the Marine Station, St. Andrews, N.B.

While there Dr. Arthur Willey (Professor of Zoology, McGill University) called my attention to the condition of some of the copepods—(*Calanus finmarchicus*—upon which he was conducting researches. Under the microscope it was seen that many parts of the tissue of copepods which had died in culture flasks were completely destroyed by masses of what appeared to be bacteria. It was particularly noticed that the axial cavity in the first antennae was entirely occupied by a dense column of writhing organisms. Tubes of nutrient broth were inoculated direct from the copepods and after two days' incubation at room temperature a definite clouding of the medium was noted.

At the request and on the suggestion of Dr. Willey I have proceeded with the examination of the cultures secured, and have obtained in pure culture the organisms concerned. Three specific strains of bacteria have been isolated.

Inasmuch as the work may have some practical significance in relation to the general subject of marine biology, and is of scientific interest, this report of the detailed studies of these organisms has been prepared.

MEDIA EMPLOYED.

I began by using various media prepared from fish concoctions in addition to the ordinary laboratory media. The latter, however, proved to be more satisfactory in every way and I have therefore confined myself to their use entirely.

Beef Peptone Agar.—Standard methods [1]—Beef extract being substituted for meat.

Beef Peptone Gelatine.—Standard methods.[1]

Glucose Agar.—1% glucose added to agar prepared as above, immediately before tubing.

Sodium Indigo Sulphate Agar.—3 per cent. sodium indigo sulphate with 2 per cent. glucose added to neutral agar, tubed and sterilized in flowing stream for three successive days.

Tochtermann's Serum Agar.—[2] For digestion test.

Löeffler's Blood Serum.—[3] " " "

Aesculin Agar.[4]—For specific reaction of organisms of the colon-aerogenes group. Loops of a broth culture spread on plates.

Neutral Red Bile Salt Agar.[5]—Ditto, ditto.

Bouillon for Voges-Proskauer reaction.[6]—

Bouillon for the Methyl Red Reaction.[7]—

Solution for reduction of Nitrates to Nitrites.—Giltay's synthetic solution was used, and also a peptone potassium-nitrate solution.

Dunham Solution for Indol Production.—1 per cent peptone, 5 per cent NaCl dissolved in distilled water, the reaction adjusted to + 10, medium cleared with white of egg, filtered, tubed and sterilized. After 7 days' incubation at 37½°C. the cultures were tested for indol by the Bohme Ehrlich test [8]; the development of a cherry red colour indicating the presence of indol.

Fermentation broths.—The various sugars, alcohols, glucosides used were prepared separately as 10 per cent solutions in distilled water, and sterilized for 15 minutes in flowing steam for three successive days. Immediately before inoculation these were added to tubes of broth made up as for the indol test—the use of peptone water without beef eliminates any risk of the reaction being masked by action on the muscle sugar—in such proportions as to give a final 1 per cent sugar or other carbohydrate broth. Dunham tubes were used for the collection of the gas. For acid production the acid fuchsin indicator of Andrade,[9] as adapted by Hollman, was used at the rate of 2 per cent.

In the preparation of the indicator I have noticed as reported by Andrade, and Hollman that the colour which results from the addition of the normal caustic soda is preceptibly affected by being left open to the air. By adding the caustic soda to freshly prepared acid fuchsin solution at intervals throughout the day, leaving the reagent meanwhile exposed to the air, I have found that 2½ cc. n/NaOH will decolorize to the proper shade of amber 100 cc. fuchsin solution.

Litmus Milk.—The milk freshly separated and tubed was sterilized for three successive days for 30 minutes in flowing steam. The litmus was made up separately; a 7 per cent solution of "Merck's" litmus in distilled water, heated in the steamer for 30 minutes and left over night in the incubator, filtered, sterilized for three successive days in flowing steam and added to the milk immediately before inoculation at the rate of 1½ per cent.

NOTE: It will be seen from page 224 that culture III of this paper exhibited an unusual degree of sensitiveness to the litmus. For this reason I now consider the proportion of the indicator added to be of some importance.

CULTURAL STUDIES.

Culture I.

Morphology.—Microscopically—24-hour-old agar culture at 37°C.—short rods varying up to 1-6 μ long and 1 μ broad; some larger forms; stains unevenly with Kuhne's methylene blue, and is Gram negative. No spores are formed and no capsule shown.

Motility.—Decided brownian movement, but not the violent agitation noted in culture III. No motility.

Cultural Characteristics:—

Agar Slope.—24 hours at 37°C. growth luxuriant, raised, slightly spreading, moist, glistening, porcelain-white, edges echinulate.

Glucose Agar Slope.—Gas, growth luxuriant, raised, moist, glistening, woolly appearance, haze, porcelain-white, spreading.

Tochtermann's Serum Agar Slope.—Resembling growth on glucose agar, but no woolly appearance. In 8 days growth had permeated medium as flakes; gas, heavy precipitate collected at base of slope.

Löeffler's Blood Serum.—Moderate, spreading, flat, no digestion, no discolouration. In 7 days no digestion; colour isabella, luxuriant, moist, slightly raised, iridiscent.

Sodium Indigo Sulphate Agar Slope.—Luxuriant, raised, moist, spreading, no reduction. In 8 days no reduction.

Gelatine Stab.—21°C. 24 hours, growth filiform, equal surface and stab. In 7 days as before; gas bubbles—presumably from the muscle sugar in the beef extract —in tube. In 6 weeks no liquefaction, growth brown, echinulate, medium unchanged.

Nutrient Broth.—37°C. 24 hours. Clouding abundant, medium clearing, flaky sediment at bottom, bluish rim at top. In 3 days flocculent yellowish-white rim at top, easily dislodged on shaking. Medium almost clear.

Potato.—Abundant along track of needle, glistening, contoured, isabella colour, growth slightly raised; in 3 days iridiscence perceptible and medium slightly browned.

Milk.—Coagulation in 24 to 30 hours; curd broken by gas bubbles. In 6 weeks curd contracted, no digestion.

Litmus Milk.—In 20 hours lilac, much gas, no coagulation; in 36 hours coagulation with gassy curd; in 5 days curd bleached; in 6 weeks no digestion.

Aesculin Agar.—Luxuriant, moist, black reaction.

Neutral Red Bile Salt Agar.—Luxuriant, raised, glistening, moist. Characteristic red reaction.

Peptone Broth + Aesculin.—Black reaction.

Gelatine Colonies.—(1st appearance) 5 days at 21°C. Surface colonies up to 1 mm. diameter, raised, slightly darker in centre, paling towards edges. Under the low power objective homogenous, granular, edges entire.

Agar Colonies.—24 hours at 37°C. Surface colonies up to 3 mm. diameter, raised, concave, glistening, yellowish-white at centre, paling towards edges, edges entire, colonies bluish by transmitted light. Under low power objective edges entire, finely granular, amorphous.

Temperature Relations:—

Thermal Death Point.—10 mns. exposure in nutrient broth at 60°C.

Optimum Temperature.—37°C. Cultures incubated at 37°, 21°, and 14°C. respectively.

Vitality on Culture Media.—Active cultures have been recovered from agar after 5 months at temperature of 15°-20°C.

Relation to Oxygen.—Facultative anaerobe; glucose agar.

Biochemical reactions:—

Indol production: Indol produced.
Reduction of nitrates: Nitrates reduced to nitrites.
Voges-Proskauer reaction: Negative.
Methyl red reaction: Acid.

Fermentation of Carbohydrates:—

Glucose.	Lactose.	Saccharose.	Maltose.	Mannite.	Dulcite.
+ +	+ +	+ +	+ +	+ +	+ +
Dextrine.	Salicin.	Raffinose.	Adonite.	Inulin.	Xylose.
+ +	+ +	+ +	+ +	+ +	+ +
Glycerine.					
+ +					

+ = acid.
++ = acid and gas.

Culturally and biochemically this organism is a variation of the *B. coli* type according to the description of Escherich.[10] The variety I have isolated differs from the original description in that it is non-motile and ferments saccharose to acid and gas. The degree of importance to be attached to any one character has been discussed at considerable length in the literature during the last thirty years; owing to the fact that this organism is used as a presumptive test for faecal contamination in systematic water analysis. Of the two variations from the original type mentioned above, the presence or absence of motility may first be considered.

There has been a tendency by some workers to consider a non-motile form of *B. coli* (Escherich)[10] as *B. aerogenes* (Escherich)[11]. This position, however, is not substantiated by the researches of Escherich and Pfaundler, MacConkey, Jackson and others. Escherich and Pfaundler[12] in describing the original *B. coli* state that generally there is motility, sometimes slight; a characteristic movement as of short forward pushes; swinging in space with sometimes no change of place is also noted. The absence of definite motion as recorded by Tafel, Frankel and others is cited in the same paper. Lembke[13] considers that motility in *B. coli* is variable. McWeeney[14] in discussing what he would regard as the genuine *B. coli* remarks: "on the motility of individuals or its absence I hesitate to lay much stress." Houston[15] in using a broad classification for the true colon group adopts his "flaginac" test which leaves open the question of motility. Durham[16] considers that all members of the true colon group are probably motile; but in the same paper states: "speaking generally morphological characters are not of much value for subdivision of these bacteria."

MacConkey[17] discusses the influence of temperature and medium on motility; and while he considers the presence or absence as important he says: "it is very difficult to arrive at a conclusion with regard to this character." Ellis[18] has proved the presence of flagella in five species of the genus *Bacterium* which were hitherto held to be non-motile; and he considers that all the genus *Bacterium* when suitably cultivated can be shown to be motile. His conclusions would appear to be not sufficiently substantiated on the data given. The English Commission on the Standardization of Methods for the bacteriological examination of water[19]; and the American Commission on Standard Methods[1] each specify motility as one characteristic of the true *B. coli*; but a comparison of the two standards reveals variance as to the significance to be attached to this specific feature. Prescott and Winslow[20] consider the sugar fermentations, particularly the fermentations of glucose and lactose, are of prime importance. Savage[21] considers motility as one of the essential characters of the true *B. coli*. Migula[22] includes *B. neapolitanus* (Emmerich)[23] which is non-motile, as identical with *B. coli* (Escherich).

Thus while the concensus of opinion is undoubtedly in favour of specifying motility as a character of the true *B. coli*, there would seem to be no justification according to present classification for excluding from this type an organism preponderatingly similar and placing it with *B. aerogenes* (Escherich)[11] on account solely of the absence of motility. Harrison[28] raises the question as to whether, provided the argument *re* motility is admitted, it removes *B. neapolitanus* to a different genus from *B. coli*.

The second variation to which I have referred (page 219) is the fermentation of saccharose to acid and gas. *B. coli* (Escherich)[10] has no action upon saccharose. Theobald Smith, cited by Prescott and Winslow[20] stated in 1893 that *B. coli* could be divided into two distinct sub-types,—the one negative to saccharose or in other words the original *B. coli*, and the other fermenting this sugar to acid and gas. Durham[16] isolated saccharose—positive organisms and gave the name *B. coli communior*, since contracted to *B. communior*. Jackson[24] has classified the organisms of the lactose fermenting type and confirms the sub-type *B. communior* of Durham. The classification of Jackson has since been adopted by the laboratory section of the American Public Health Association,[1] and on this continent has received almost general approval. Using saccharose and dulcite as differential fermentation tests Jackson considers

those organisms positive to lactose and dulcite as *B. coli* (Escherich)[10]; positive to lactose, saccharose and dulcite as *B. communior* (Durham)[16]; positive to lactose and saccharose but negative to dulcite as *B. ærogenes* (Escherich)[11], positive to lactose but negative to saccharose and dulcite as *B. acidi-lactici*.[24] Further subdivision according to the action on mannite and raffinose are used for further differentiation.

MacConkey uses the Voges-Proskauer reaction as one of his differential tests and finds that the true *B. coli* is always Voges-Proskauer negative, while the *B. ærogenes* type is Voges-Proskauer positive. In the same paper he revives the name *B. neapolitanus* (Emmerich)[23] and uses this nomenclature for his saccharose positive dulcite positive strains instead of the name given by Durham—*B. communior*. MacConkey obtained a pure culture labelled *B. neapolitanus* from Kral, and out of 480 coli-like organisms isolated from human and animal fæces he found that 23 per cent gave biochemical reactions identical with the Kral culture used by him as control. He states that he cannot agree with Migula in describing *B. neapolitanus* (Emmerich) as identical with *B. coli* (Escherich). As, however, the differentiation by means of carbohydrates other than glucose and lactose has been amplified since the classification by Migula, the conclusions of both Migula and MacConkey on this particular point are perfectly legitimate. Jordan[25], in designating the saccharose-positive dulcite-positive group uses *B. communior* and *B. neapolitanus* interchangeably; biochemically this as correct, but the former is motile (16), the latter non-motile[23]. Levine[26] who apparently follows MacConkey has lately studied 333 strains of lactose fermenting bacteria from various sources. He goes one step further and giving *B. neopolitanus* its original character of non-motility according to Emmerich[23], uses that nomenclature to include non-motile forms of *B. communior* (Durham). To say the least it is interesting to revive *B. neapolitanus* as a sub-type of *B. coli* (Escherich) in view of the following statement by Jordan[25a]: "According to a strict application of the rules of priority, the bacillus now known as *B. coli* should be called *B. neapolitanus*." The dates of the original publication by Emmerich [23a], and Escherich[10], of course bear out Jordan's statement.

However, according to the first descriptions of Emmerich[23] and Escherich[10] the former found a non-motile strain and the latter a motile strain of a lactose fermenting organism. Later work already referred to has separated these two strains on the basis of saccharose fermentation[28]. We thus have two features in which the respective strains differ. A propos of the stand taken by Durham and McConkey, Harrison[28] opens the question as to whether it is legitimate to name as a species, an organism differing only in the fermenting of one sugar.

It would therefore seem legitimate, on the ground of present day classification, to tentatively characterize the organism I have isolated-a non-motile, lactose, saccharose, dulcite positive, Voges-Proskauer negative strain,—as a variety of the sub-type *B. neapolitanus* of the classic *B. coli* type of Escherich. To use *B. neapolitanus* conflicts with the nomenclature *B. communior* more usually accepted for the strains giving identical reactions. If motility is considered, *B. neapolitanus* and *B. communior* are not strictly the same; but to use the single characteristic, absence or presence of motility, to separate *B. communior* and *B. neapolitanus*, and at the same time to say that a non-motile form of colon is identical with a motile form may seem inconsistent.

The difficulty can be overcome by the tentative classification of the organism I have isolated as a non-motile strain of the sub-type *B. communior* (Durham) of the type *B. coli* (Escherich); or to take the differentation further, as *B. neapolitanus*, a sub-type of *B. coli* (Escherich).

Culture II.

Morphology.—Microscopically—24-hours-old agar culture at 37 C. rods varying up to 1·6 μ long and ·8 μ broad; some not much longer than broad; stains evenly with Kühne's methylene blue and is Gram negative. No spores; no capsules have been demonstrated.

Motility.—Rapid movement, darting to and fro, many revolve as on an axis.

Cultural Characteristics:

Agar Slope.—24 hours at 37°C.—moderate, bluish by transmitted light, moist, glistening, slightly raised, later becoming by transmitted light yellowish in centre gradually merging into transparency.

Glucose Agar Slope.—Gas, growth moderate to luxuriant, glistening, slightly raised.

Tochtermann's Serum Agar Slope.—Moist, slightly raised, bluish by transmitted light, spreading discrete colonies, gas. In 8 days growth had become yellow, much water of condensation, heavy greyish-white precipitate at base of slope.

Loeffler's Blood Serum.—Moderate, filiform, moist, glistening, no liquefaction, no discolouration. In 7 days no digestion, no discolouration.

Sodium Sulphate Agar Slope.—Raised, spreading, moist, no reduction. In 8 days no reduction.

Gelatine Stab. 21°C., 24 hours, growth filiform, equal surface and stab; 7 days, tendency to echinulate. In 6 weeks no liquefaction, growth yellowish-brown; characteristic lateral growths resembling a poplar tree against the horizon; medium unchanged.

Nutrient Broth.—37°C. 24 hours. Clouding abundant, no pellicle, no sediment, bluish rim at top. In 1 week, slight sediment; otherwise no change.

Potato.—Moderate, flat, yellowish-white along track of needle.

Milk.—In 6 weeks no change.

Litmus Milk.—Varies from no change to a tint slightly more alkaline than control; blue rim at top.

Aesculin Agar.—Black reaction, growth less luxuriant than in Culture I.

Neutral Red Bilesalt Agar. Moderate, pink reaction.

Peptone Broth + Aesculin.—Black reaction.

Gelatine Colonies.—5 days at 21°C.—colonies up to 5 mm. diameter; under low power objective granular; edges lobular to contoured, centre dark with paling towards edges. Deep surface colonies granular centre with dark concentric rings.

Agar Colonies.—24 hours at 37°C.—surface 1 mm. diameter, raised, concave, bluish by transmitted light, round, smooth, edges entire. Under low power objective granular, edges entire.

Temperature Relations:—

Thermal death point: 10 minutes exposure in nutrient broth at 55°C.

Optimum temperature: 37°C.; cultures incubated at 37°C., 21°C. and 14°C. respectively.

Vitality on Culture Media:—

Active cultures have been recovered from agar tubes after 5 months at temperature of 15°-20°C.

Relation to Oxygen:—

Facultative anaerobe; glucose agar.

Biochemical reactions:—

Indol production: Indol not produced.
Reduction of nitrates: Nitrates reduced to nitrites.
Voges-Proskauer reaction: Positive, after 6 hours.
Methyl red reaction: Faint acidity, shortly followed by reversion to alkalinity.

Fermentation of Carbohydrates:—

Glucose.	Lactose.	Saccharose.	Raffinose.	Maltose.	
++	± −	++	− −	++	
Mannite.	Dulcite.	Adonit.	Salicin.	Dextrine.	Inulin.
++	− −	− −	++	++	− −
Xylose.	Glycerine.				
++	++ (slowly).				

+ = acid.
++ = acid and gas.

NOTE.—The fermentation of lactose to acid is faint, and in two days reduction is noted.

The classification of this culture must be purely tentative. It will be seen that while saccharose, maltose, mannite, salicin and dextrin are fermented to acid and gas, the organism fails to ferment lactose to gas and only faintly to acid. This has persistently been the case through several months; on one occasion, however, a small bubble of gas—1 mm. diameter—appeared in a Durham tube. This I have been unable to obtain since, confirming in triplicate. MacConkey states: "It has been my experience that where an organism produces acid and gas in one medium and apparently only acid in another, under proper subcultivation the organism will produce gas in the second medium."[17] Harrison in this laboratory has frequently cited to me verbally his own experience in this matter, which bears out the statement of MacConkey. While the organism is definitely motile it differs from *B. cloacae* of Jordan[29] in that it fails after three months to liquefy gelatine, fails to ferment lactose to gas, and fails to coagulate milk after several weeks. Rogers Clarke and Evans[30] found that the group of the types they isolated from grains—Group B—fermented to acid and gas glucose, saccharose, mannite, glycerine and adonit, but like my culture failed to ferment lactose; on the other hand this group liquefied gelatine.[30] These workers consider that such group has at best only a slight connection with the *colon-ærogenes* group. Taking the classification adopted by the American Public Health Association[1] the culture would be ruled out of the *colon-ærogenes* group at once on account of its failure to produce gas from lactose; further, milk is not coagulated. Certain of the biochemical reactions would tend to suggest the *Gaertner* group. According to Besson[31] the organisms of this group are negative to lactose, saccharose, salicin, raffinose and inulin; while those carbohydrates to which the group is positive include dulcite. This organism, it will be noted, is negative to dulcite, lactose and inulin but positive to saccharose and salicin. Jordan[32] in a study of 74 strains of the *Gaertner* group cites that the reaction to dulcite and xylose is variable, but includes dextrine among the fermentable substances not attacked; thus establishing at once a similarity and a variation respectively as compared with the organism here described. In the same paper Jordan describes strains where reaction to litmus milk cannot be differentiated from the control. Savage[33] in a classification of the *Gaertner* group divides such into two sub-groups:—

a. *True-Gaertner bacilli;*
b. *Para-Gaertner bacilli;*

to which he had previously drawn attention in reports to the Local Government Board, 1906-7-8. Citing from Savage: "The bacilli of the para-Gaertner sub-group are a number of organisms, for the most part unnamed, which appear to be not very uncommon in the healthy animal and human intestine, and which are of chief interest from their close resemblance to *true-Gaertner* bacilli. . . . They can only be culturally differentiated from the *true-Gaertner* organisms by an extended series of fermentation tests while they fail to be agglutinited by immunizing animals with

any of the members of the *true-Gaertner* sub-group. They are also for the most part non-pathogenic. They have not so far been found as a cause of disease in man or in animals."

Until I am able to secure for comparative cultural tests strains of this sub-group from Dr. Savage, it would not be wise to attempt a more definite classification of the organism herein discussed. In view, however, of the decided variation from the Voges-Proskauer type of the *colon-aerogenes* group as lately given by Levine,[29] and considering the many cultural features and fermentative reactions which suggest at any rate a distant relationship to the *para-Gaertner* group, it seems not undesirable to suggest that based on the cultural features and biochemical reactions this organism be considered tentatively as an atypical form of the *para-Gaertner* group according to Savage.[33]

Culture III.

Morphology.—Microscopically the organism appears as a coccus, in pairs, in masses, and as short streptococci; the average diameter from a 24-hour-old agar culture at 37° C. being ·8 μ, stained with Kühne's methylene blue. The organism is Gram positive and non-spore-forming; capsules faintly discernible.

Motility.—Tests for motility made in hanging drop of condensation water from a young agar culture. No motility. Violent agitation can be noticed, and rotation of the cells as on an axis, but the position in the drop is unchanged.

Cultural Characteristics:—

Agar Slope.—24 hours at 37° C. growth scanty, bluish by transmitted light, filiform, flat, with later a tendency to spreading.

Glucose Agar Slope.—Growth moderate, heavier than on agar, discrete colonies, flat, spreading, glistening.

Tochtermann's Serum Agar Slope.—Growth scant to moderate, bluish by transmitted light, heavy clouding of the condensation water. In 5 days slight digestion of the medium noted.

Lœffler's Blood Serum.—Growth filiform, medium channelled and slightly darker in colour. In 5 days growth glistening, yellowish, slight digestion.

Sodium Indigo Sulphate Agar Slope.—Faint growth, no reduction of colour, 24 hours. In 14 days reduced to reddish brown.

Gelatine Stab.—21° C. In two days liquefaction beginning. In 7 days stratiform liquefaction for ⅓ of tube, even clouding with yellowish flocculent precipitate at bottom. Liquefaction complete in 1 month.

Nutrient Broth.—37° C. even clouding, moderate, no pellicle, no sediment; later medium cleared.

Potato.—Barely discernible growth in 24 hours. In 3 days faint growth, flat, spreading, white, metallic lustre.

Milk.—37° C. In 36 hours weak coagulum, no gas noted. In 72 hours digestion had begun, a clear lemon coloured liquid extending for ⅓ tube. In 7 days tube half fluid, curd soft, gelatinous, bright and of a solidity resembling macaroni; easily desintegrated on shaking; after 2 months some curd still remaining, lemon yellow in colour, consistency as before.

Litmus milk.—The reaction of the organism to this medium is unusual, and it is due to the sensitiveness here discovered that I have adopted the uniform percentage of litmus, noted on page 218. If litmus be added at the rate of 1½ per cent coagulation preceded by bleaching takes place within 36 to 48 hours. Digestion then begins and proceeds slightly more rapidly than in the milk, the contents of the tube varying in colour from a lemon yellow to claret with decided fluorescence in 72 hours. In 2 months digestion is not complete, 1-2 cm. of a jelly-like claret coloured curd remaining.

If the quantity of litmus added be more than 1½ per cent the reaction is quite different, varying according to the percentage of litmus added. There may or may not be coagulation, the colour varying from isabella to a muddy purpureus; flakes of tinted curd can later be noted. In 2 months a condition resembling broken jelly of a variety of shades of purpureus has been recorded. A note referring to this phenomenon in greater detail is being published elsewhere.

Aesculin agar.—Growth moderate, flat, dry, brown to black.

Neutral Red Bile Salt Agar.—Growth scant, no characteristic colour reaction.

Peptone Broth Aesculin.—Black in 12 hours.

Gelatine Colonies—(1st appearance).—21°C. 4 days, punctiform to pinhead colonies, depression in medium commencing; under the low power objective structure compact, finely granular, paler towards the edges; edges ciliate.

Agar Colonies.—37° C. growth slow. 24 hours colonies ·5 mm. in diameter, growth tends to be subsurface. Under the low power objective colonies round or eliptical, edges entire to undulate, internal structure granular, dark halo in surrounding medium.

Temperature Relations.—

Thermal death point. 10 minutes' exposure in nutrient broth at 60°C.

Optimum temperature. 37°C.; cultures incubated at 37°C., 21°C. and 14°C. respectively.

Vitality of Culture Media:—

Active cultures have been recovered from agar tubes after 5 months at temperature of 15°-20°C.

Relation to Oxygen.

Facultative anaerobe. Under anærobic condition on glucose agar, growth visible in 24 hrs. at 37°C.

Biochemical Reactions:—

Indol production: no indol in 7 days.
Reduction of nitrates: no reduction to nitrites.
Voges-Proskauer reaction: negative.
Methyl red reaction: acid to methyl red.

Fermentation of Carbohydrates:—

Glucose.	Lactose.	Saccharose.	Maltose.	Mannite.	Dulcite.
+	+	+	+	+	– –
Dextrin.	Salicin.	Raffinose.	Adonite.	Inulin.	Xylose.
+	+	– –	– –	– –	– –
Glycerine.					
– –					

\+ = acid.
++ = acid and gas.

In accordance with the cultural results this organism is properly included among the liquefying streptococci. Winslow [34] takes the *Str. gracilis* of Escherich, Lehmann and Neumann as the "type centre" of these liquefiers. He considers that the various streptococci which peptonise gelatine more or less actively are variants of this type; intermediate between it and some of those characterized by Andrews and Horder [35].

I find, however, a closer resemblance to an organism described by MacCallum and Hastings[36] as *Micrococcus zymogenes.* This was isolated from a fatal case of acute endocarditis, and while it shows the same main characteristics as *Str. gracilis*, it

liquefies serum slightly and subsequent to coagulating milk digests the clot. This organism was later found by Birge.[37] It is in the two last characteristics that I find the close resemblance to *M. zymogenes* noted above. The original description of *Str. gracilis* of Escherich cited by Winslow [34] includes non-liquefaction of blood serum and failure to coagulate milk; but summing up the variations Winslow provisionally defines his "type centre" *Str. gracilis* as follows: Small coccus, appearing in chains, ferments lactose and coagulates milk, may ferment mannite and salicin, liquefies gelatine actively.

While the organism I have described appears to have certain particular characteristics, I hesitate to depart from Winslow's view regarding the relationship of the variants in his tentative group of streptococcus liquefiers [34]. I conclude therefore that this organism which culturally and biochemically is identical with the *M. zymogenes* of MacCallum and Hastings [36] should be placed as a variety of the type *Str. gracilis*.

SUMMARY AND CONCLUSIONS.

1. Three strains of bacteria have been isolated from the destroyed tissue of copepods which had died in culture flasks.

2. Summarized, the biological features are as follows:—

	I. Rod-form.	II. Rod-form.	III. Coccus.
Gram's Stain	-		+
Spores	-		−
Capsule			+
Motility	-	+	−
Agar	Luxuriant	Moderate	Scant.
Gelatine	No liquef.	No liquef.	Liquef.
Potato	Abundant	Moderate	Scant.
Löeffler's Blood Serum	No digestion	No digestion	Slight digest.
Milk	Coagulat.	No change	Coag. and digest
Thermal death pt	60°C	55 C	60 C.
Optimum temperature	37 C	37 C	37°C.

3. Summarized, the biochemical reactions are:—

	I.	II.	III.
Indol	+	−	−
Nitrate reduction	+	+	−
Voges-Proskauer		+	−
Methyl Red	Acid.	Faintly acid, later alkal.	Acid.
Glucose	++	++	+
Lactose	+	± −	+
Saccharose	++	++	+
Raffinose	++	− −	− −
Maltose	++	++	+
Mannite	++	++	+
Lulcite	++	− −	− −
Adonite	++	− −	− −
Salicin	++	++	+
Dextrine	++	++	+
Inulin	+	− −	− −
Xylose	++	++	− −
Glycerine	++	++	− −

+ = acid. ++ = acid and gas.

4. Based on their cultural features and biochemical reactions the organisms are classified as follows:—

Culture I.—Tentatively as a non-motile strain of the sub-type *B. communior* (Durham) of the type *B. coli* (Escherich); or to take the differentiation further, as *B. neapolitanus,* a sub-type of *B. coli* (Escherich).

Culture II.—Considered tentatively as an atypical form of the *Para-Gaertner* group after Savage.

Culture III.—Identical with *M. zymogenes* and placed as a variety of the type of liquefying streptococci, *Streptococcus gracilis.*

5. No inoculations of these cultures have been made into healthy copepods owing to distance from the sea.

6. It is not legitimate to draw any definite conclusions regarding the relationship of these organisms to the destruction of the copepods, as no inoculation experiments have been carried out, and the postulates of Koch have not yet been satisfied. According to the descriptions presented, however, the evidence is strong in favour of Culture III being a possible causal agent.

I wish to thank very cordially Dr. F. C. Harrison for his kindness in reading the proofs, and particularly for his valuable and critical assistance with regard to the classification of the *B. coli* group; and Dr. Arthur Willey for the initial suggestion that I should undertake the investigation.

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XIV

BATHYMETRIC CHECK LIST OF THE MARINE INVERTEBRATES OF EASTERN CANADA WITH AN INDEX TO WHITEAVES' CATALOGUE.[1]

(By E. M. Kindle and E. J. Whittaker.)

INTRODUCTORY NOTE.

The primary object of this paper is to bring together in columnar form all of the available information relating to the depth at which the various species of marine invertebrates live which are known from the Atlantic coastal waters of Canada. The value of the segregation and graphic presentation of any group of facts relating to invertebrate environment is obvious from the standpoint of ecology. The significance of many factors in the environment of faunas becomes clearly apparent only when treated in this way. There is no factor in marine faunal environment which more readily lends itself to this kind of analysis than bathymetric data. Such data though nearly always given by marine Zoologists are generally placed obscurely in the midst of extraneous matter and almost never shown in tabular or easily comprehensible form.

Bathymetric range of fossil faunas is a factor which enters into many problems in palæontological correlation and it is very desirable that the palæontologist as well as the zoologist should have access to the recorded bathymetric data in tabular form relating to present marine faunas. There perhaps is no group of facts pertaining to recent faunas of greater significance to stratigraphic palæontologists than those relating to the bathymetric range of species. The geologic importance of knowing the present range in depth of the marine shells now living in the Gulf of St. Lawrence is clearly apparent to the geologist who attempts to use the fossil Pleistocene shells of the St. Lawrence valley in interpreting the details of its Post-glacial history. The geological and zoological importance of this class of data has induced the authors to bring together in columnar form the recorded information regarding the bathymetric range of species as recorded by Dr. Whiteaves together with the data published by later authors. In order to facilitate rapid comparative examination of the bathymetric data it has been recorded in columnar form, five columns being used. The first three of these columns correspond respectively to the intertidal or beach, the laminarian and the coralline zones. The intertidal zone extends between low and high tides; the laminarian zone reaches from low-water mark to 15 fathoms; the fourth column includes depths of from 50 to 100 fathoms which may be termed the subcoralline zone. The 100 fathom line marks the approximate margin of the continental shelf. All of the records exceeding this depth have for convenience been placed together in a single column.

The bathymetric check list has been brought up to date by the examination of the papers on the marine invertebrates of Eastern Canada which have appeared since the publication of Dr. Whiteaves' paper. Where these later contributions have furnished new bathymetric information its source is indicated by a number following the species name which refers to the bibliographic list at the end of this paper.

The authors have also undertaken in the following pages to make more easily accessible and usable the large amount of information on the marine faunas of Eastern Canada contained in Dr. Whiteaves' Catalogue of the Marine invertebrata of Eastern Canada[2] by the preparation of an index to it. Many zoologists have doubt-

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[1] Published with the permission of the Director of the Canadian Geological Survey.
[2] Geol. Survey of Canada, 1901.

less, like Professor Prince, felt that the usefulness of this catalogue "would be vastly increased by the addition of an index."[1] The importance of this volume to the zoologist is evident and its interest to the geologist dealing with the Pleistocene is almost equally great. The student of the Pleistocene fossils of eastern Canada and the New England States finds it desirable to refer constantly to this valuable work. The omission from it of an index however, has made such reference difficult and wasteful of time and caused the student of both the Pleistocene and Recent shells to make much less use of the catalogue than its value warrants. The present index to the species of this catalogue, which number more than 1,000, is intended to remove this bar to frequent and easy reference to the wealth of information concerning the Atlantic coast faunas of Canada which was brought together by Dr. Whiteaves.

In a paper having the object and scope of the present one, it does not appear desirable to attempt any revision of the nomenclature. The nomenclature adopted by Whiteaves has therefore been followed throughout and where later authors have used names different from those accepted by Whiteaves for the same forms cross references to the latter have been used. All of the names which appear in the synonomy of the Whiteaves' catalogue will be found in the general index.

Bathymetric Tables.[2]

	Bathymetric Range.					
—	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms. 1–15	15–50	50–100	100 †
Protozoa.						
Reticularia (Foraminifera).						
Ammodiscus incertus, d'Orbigny						
Biloculina oblonga Montfort	D.W..					x
Biloculina ringens Lamarck 35	6–313		x	x	x	x
Bolivina punctata d'Orbigny 35	I.T.-S.W.	x	x			
Bulimina aculeata d'Orbigny	D.W.					x
Bulimina elegantissima d'Orbigny	18–D.W.			x	x	x
Bulimina pyrula d'Orbigny	7–250		x	x	x	x
Cassidulina crassa d'Orbigny	30–D.W.			x	x	x
Cassidulina laevigata d'Orbigny	10–D.W.		x	x	x	x
Cornuspira foliaceus Philippi	18–250			x	x	x
Cristellaria crepidula F. and M.						
Cristellaria lituus d'Orbigny						
Cristellaria rotulata Lamarck						x
Globigerina aequilateralis ? 11	F.					
Haplophragmium canariense d'Orbigny 35	5½–200		x	x	x	x
Haplophragmium cassis Parker	10–20		x	x		
Hippocrepina indivisa Parker	16–20			x		
Lagena apiculata Reuss	100+					x
Lagena distoma P. and J.	10–313		x	x	x	x
Lagena globosa W. and J.	16–313			x	x	x
Lagena laevis Montagu	250					x
Lagena marginata W. and B.	30			x		
Lagena melo d'Orbigny	100+					x

[2] Note.—The Maximum and minimum depth recorded for each species is indicated in the first column. The bathymetric range is also indicated graphically by checking each species in each of the columns in which its range falls, thus facilitating rapid comparative examination of the recorded data. Sometimes the information regarding bathymetric range is of an approximate or comparative nature and in such cases some one of the following symbols has been used for expressing range not recorded in linear units.

o—Low water mark.
D.W.—Deep water.
F.—Free swimming.
I.T.—Intertidal.
P.—Parasitic.
S.W.—Shallow water.
<3—Depths less than 3 fathoms.
>100—depths greater than 100 fathoms.
10—Depth in fathoms.

[1] Ottawa Naturalist, vol. 15, 1912, p. 171.

Bathymetric Tables—*Continued.*

—	Min. and Max. Depth.	Bathymetric Range. Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 †
Protozoa—*Con.*						
Reticularia (*Foraminifera*)—Con.						
Lagena ornata Willdenow...............	30–100 ?.			x	x ?	x ?
Lagena semistriata Willimason...	30–100 ?.			x	x ?	x '
Lagena squamosa Montagu	30			x·		
Lagena striatopunctata P. and J...	30			x		
Lagena sulcata P. and J.......	16 50			x		
Miliolina agglutinans d'Orbigny	10 50		x	x		
Miliolina bicornis W. and J. 35...........	2–50		x	x		
Miliolina ferussacii d'Orbigny.....	35–50			x		
Miliolina oblonga Montfort 35..	2–50....		x	x		
Miliolina secans d'Orbigny..	<50			x		
Miliolina seminulum L. 35.....	2–313.		x	x	x	x
Miliolina subrotunda Montfort..	<50			x		
Miliolina tricarinata d'Orbigny	18 50			x		
Miliolina trigonula d'Orbigny...	<50					
Nodosaria (Dentalina) communis d'Orbigny...	30–50.			x		
Nodosaria (Glandulina) laevigata d'Orbigny..	30–313			x	x	x
Nodosaria (Dentalina) pauperata d'Orbigny..	313..			....	..	x
Nonionina scapha F. and M..........	35–D.W.			x	x ?	
Nonionina labradorica.....	15–100			x	x	x
Patellina corrugata Williamson 35..............	I.T.-40..	x	x	x		
Polymorphina compressa d'Orbigny	10–50.		x	x		
Polymorphina lactea W. and J. 35............	2–313.		x	x	x	x
Polystomella arctica P. and J.....	30–50.		......	x		
Polystomella striatopunctata F. and M. 35.	2–300..		x	x	x	x
Pulvinulina karsteni Reuss.........	30–250		.....	x	x	x
Reophax findens Parker..................	10–50.		x	x		
Reophax scorpiurus Montfort..........	16–20.		......	x		
Rhabdammina abyssorum M. Sars.	20–D.W..		.....	x	x	x
Rhabdammina discreta Brady.................						
Rotalia beccarii Linnaeus 35...	2–313...		x	x	x	x
Spiroplecta biformis P. and J............						
Textularia agglutinans d'Orbigny.						
Textularia variabilis Willdenow..................		..		x	x	
Trochammina inflata Montfort..............	10–40.		x	x		
Truncatulina lobatula W. and J. 35.............	4-D.W..		x	x	x	x ?
Uvigerina angulosa Willdenow.	D.W..				x	x
Uvigerina pygmaea d'Orbigny..................	30–90.			x	x	
Vaginulina spinigera Brady.	D.W..				x	x
Valvulina conica P. and J..	D.W..				x	x
Verneuilina polystropha Reuss 35..........	10–20		x	x		
Virgulina squamosa d'Orbigny.......						
Silicoflagellata, Radiolaria and Ciliata.						
Acanthonia echinoides (Clap. & Lach) 11.......	F...					
Acanthostaurus pallidus F..........	F					
Amphorella subulata (Ehrb) Daday 11..						
Codonella ventricosa 11.........................						
Codonella lagenula (Clap & Lach) 11........						
Cyttarocyclis denticulata var. gigantea Brandt. 11						
Distephanus aculeatus (Ehrenberg).	S.W.–313..		x	x	x	x
Distephanus speculum var. regularis Lemmermann 11..						
Ebria tripatrtita (Schum) Lemmermann 11......						
Plagiacanthus arachnoides Clap. 11...........	F.					
Ptychocyclis urnula Clap. & Lach. 11...........						
Strombidium sulcatum C. & L. 11................						
Tintinnopsis beroidea Stein 11....................						
Tintinnopsis campanula Ehrb. Daday 11.						
Tintinnopsis davidow Daday 11......						
Tintinnopsis cylindrica 11.............						
Tintinnopsis lobiancoi 11.						
Tintinnus acuminatus (C. & L.)11..						
Tintinnus obliquus (C. & L.) 11...........						

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range. Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 †
Porifera (Sponges).						
Calcarea.						
Amphoriscus thompsoni Lambe	60				x	
Grantia canadensis Lambe	22–56			x	x	
Heteropia rodgeri Lambe	60				x	
Leucosolenia cancellata Verrill	60				x	
Sycon asperum Lambe	56				x	
Sycon protectum Lambe	56–60				x	
Demospongiae.						
Artemisina suberitoides Vosmaer	85				x	
Chalina oculata (Pallas)						
Cladorhiza abyssicola M. Sars	200					x
Cladorhiza grandis Verrill	D.W.					x
Cladorhiza nordenskioldii Fristedt	200					x
Clathria delicata Lambe	3–6 ?		x			
Cliona celata Grant 35	2–19		x	x		
Craniella cranium (Muller)	20–30			x		
Desmacella peachii (Bowerbank) var. groenlandica Fristedt	130–200					x
Desmacidon (Homaeodictya(palmata (Johnston) 35, 47	11–20		x	x		
Esperella lingua (Bowerbank)	75–80				x	
Esperella modesta Lambe						
Eumastia sitiens O. Schmidt	22			x		
Gellius arcoferus Vosmaer	75–80				x	
Gellius flagellifer Ridley & Dendy	38–80			x	x	
Gellius laurentinus Lambe	60-130				x	x
Halichondria panicea Johnston 35	6–22		x	x		
Iophon chelifer Ridley & Dendy	100				x	
Myxilla incrustans (Johnston)						
Phakellia ventilabrum (Johnston)	56				x	
Polymastia mamillaris (Muller)	120 210					x
Polymastia robusta Bowerbank 35	17–85			x	x	
Quasillina brevis (Bowerbank)	85				x	
Reniera mollis Lambe	30–60			x	x	
Reniera rufescens Lambe						
Stylocordyla borealis (Loven)	85–220				x	x
Suberites ficus (Johnston)	1–6 ?		x			
Suberites hispidus (Bowerbank)	212					x
Suberites montalbidus Carter	20–30			x		
Tentorium semisuberites (Schmidt)	50–250				x	x
Thenea muricata (Bowerbank)	220–250					x
Trichostemma hemisphaericum M. Sars	112					x
Coelenterata.						
Hydromedusæ and Scyphomeduse.						
Acaulis primarius Stimpson	5–15		x			
Aeginopsis laurenti Brandt 16			x			
Aglantha rosea Forbes 16	25 F					
Aglaophenopsis cornuta (Verrill)	200		x	..	....	x
Antennularia antennina (L)	10–60			x	x	
Aurelia flavidula Peron & Lesueur	F.					
Bouganvillia superciliaris (L. Agassiz) 16, 35	25			x		
Bouganvillia carolinensis (McCrady) 31	I.T.	x				
Calycella syringa (L) 16, 35	25–313			x	x	x
Campanularia amphora (Agassiz) 16, 35, 43	I.T.–S.W.	x	x			
Campanularia caliculata Hincks = Eucopella caliculata (Hincks) 31 = Oxopyxis caliculata 43	o–100		x	x	x	
Campanularia flexuosa Hincks 43	I.T.–10	x	x			
Campanularia groenlandica Levinsen 31,43	I 50		x	x		

Bathymetric Tables—*Continued.*

—	Min. and Max. Depth.	Inter-tidal Zone.	Bathymetric Range. Fathoms. 1–15	15–50	50–100	100
Coelenterata —*Con.*						
Hydromedusæ—Con.						
Campanularia hincksii Alder 35, 43..	o–144....		x	x	x	x
Campanularia integra Linnaeus 43...	I–100		x	x	x	
Campanularia magnifica Fraser 31, 43..	50–72				x	
Campanularia neglecta (Alder) 31, 35, 43..	I.T.–16.	x	x	x		
Campanularia verticillata (L) 43..........	I–330		x	x	x	x
Campanularia volubilis (Pallas) 24.......	o–110.....		x	x	x	x
Catablema vesicaria (A. Agassiz) 16.						
Cladocarpus pourtalesii Verrill...........	112–300.					x
Cladocarpus speciosus Verrill.	200					x
Clava leptostyla Agassiz 31, 35...	I.T.-20..	x	x	x		
Clytia johnstoni (Alder) 31, 43....	o–110.....		x	x	x	x
Clytia noliformis McCready 43............	I–110.		x	x	x	x
Cryptolaria triserialis Fraser 31.........	20			x		
Cuspidella grandis Hincks..	15		x			
Cyanea arctica Peron & Lesueur 16........						
Dicoryne flexuosa G. O. Sars.............	50–125				x	x
Diphasia fallax (Johnston) 31.............	4–55		x	x	x	
Diphasia mirabilis Verrill = Selaginopsis mirabilis Verrill 31.	50–60.				x	
Diphasia rosacea (L) 31....	5–50		x	x		
Diphyopsis campanulifera (Eschscholtz) 16, 35 .						
Eudendrium capillare Alder 35.....	45.......			x		
Eudendrium cingulatum Stimpson.	20			x		
Eudendrium dispar Agassiz 31.	1–20		x	x		
Eudendrium rameum (Pallas) 35..	100				x	
Eudendrium ramosum (L) 31......	6–100.		x	x	x	
Eudendrium tenue Agassiz 31, 35....	I.T.-15...	x	x			
Filellum expansum Levinsen 31...............	5.		x			
Filellum serpens (Hassall) 31.........	50			x		
Gonothyraea gracilis (Sars) 31, 43...........	1–110		x	x	x	x
Gonothyraea loveni (Allman) 31, 35, 43	1–55		x	x	x	
Grammaria abietina M. Sars 31............	25–60			x	x	
Grammaria gracilis Stimpson.........						
Halecium beani (Johnston) 31, 35.	5–50		x	x		
Halecium halecinum (L) 35......	3–30		x	x		
Halecium minutum Brock 31	50			x		
Halecium muricatum (Ellis & Solander) 31 .	30–50			x		
Halecium sessile Norman..	212.					x
Halecium tenellum Hincks 31, 35........	50			x		
Halyclystus auricula Clark 16......	o 5...		x			
Hydractinia echinata Johnston 31, 35, 47....	I.T.–60.	x	x	x	x	
Hydrallmania falcata (L) 31.........	o–110...		x	x	x	x
Lafoea dumosa (Fleming) 31.....	20			x		
Lafoea fruticosa Sars 31..	20			x		
Lafoea gracillima (Alder) 31.....	45–60			x	x	
Lafoea pygmaea Alder 31.........	25			x		
Lafoea robusta Verrill..	120–200					x
Lafoea symmetrica Bonnevie 31..	20			x		
Lucernaria quadricornis Muller........	4–10		x			
Manania auricula Clark.........						
Melicertum campanula Fabricius 16, 35.........	5.		x			
Monocaulus glacialis (M. Sars) 47 = Corymorpha pendula Agassiz 31.....................	o–50.....		x	x		
Myriothela phrygia (Fabricius)........						
Obelia commissuralis McCready 31, 35, 43	I.T.–10..	x	x			
Obelia dichotoma (L) 31, 35, 43.	I.T.–10	x	x			
Obelia gelatinosa (Pallas) 35 = Obelaria gelatinosa 43.....	I.T.–30.	x	x	x		
Obelia geniculata (L) 16, 31, 35, 43...........	o–40...		x	x		
Obelia longissima (Pallas) 35, 43...	I 80		x	x	x	
Obelia pyriformis Verrill 35........	I.T.	x				
Opercularella lacerata (Johnston) 31.........	I.T.	x				
Phialidium languidum (L. Agassiz) = Oceania languidum 35........................						

BATHYMETRIC TABLES—*Continued.*

	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 x
COELENTERATA—*Con.*						
Hydromedusæ—Con.						
Physalia pelagica Lamarck	F.					
Polycanna groenlandica (Peron & Lesueur)						
Ptychogastria polaris Allman 16	60				x	
Ptychogena lactea A. Agassiz						
Sarsia princeps Haeckel 16	5		x			
Sertularella conica Allman 31	50			x		
Sertularia abietina (L.) = Abietinaria abietina 31, 35	51				x	
Sertularia filicula Ellis & Solander	20			x		
Sertularia fusiformis Hincks	200					x
Sertularia latiuscula Stimpson						
Sertularia polyzonias L. & var. gigantea Hincks = Sertularella polyzonias (Linn) 31, 35	10–60		x	x		
Sertularia producta Stimpson						
Sertularia pumila L. 31, 35	I.T.–12.	x	x			
Sertularia rugosa L.	30–D.W.			x	x	x
Sertularia tricuspidata Alder = Sertularella tricuspidata Alder 31	40–60			x	x	
Staurophora laciniata (L. Agassiz)16						
Syncoryne mirabilis (L. Agassiz) = Sarsia mirabilis (L. Agassiz) 16, 35	5		x			
Thamnocnidia larynx (L) = Tubularia larynx 31, 35	5–25		x	x		
Thamnocnidia tenella Agassiz = Tubularia tenella 31	0–40		x	x		
Thecocarpus myriophyllum (L)	30–60			x	x	
Thuiaria argentea (Ellis & Solander) 31, 35	0–110		x	x	x	x
Thuiaria articulata (Pallas)	45			x		
Thuiaria cupressina (L) 35	I.T.–100	x	x	x	x	
Thuiara lonchitis Ellis & Solander 31	50			x		
Thuiara thuja (L) 35						
Tiara pileata Forskal 16						
Tiaropsis diademata (L. Agassiz) 35						
Trachyneme digitale (O. Fabricius)	15		x			
Tubularia crocea (Agassiz) 31, 35	0–25		x	x		
Tubularia indivisa (L)	45			x		
Alcyonaria.						
Acanella normani Verrill	410					x
Acanthogorgia armata Verrill	300					x
Actinauge nexilis Verrill	200–300					x
Actinauge verrillii McMurrich	30–300			x	x	x
Actinernus nobilis Verrill	200–300					x
Actinopsis whiteavesii Verrill	200					x
Actinostola callosa Verrill	45–300			x	x	x
Alcyonium carneum L. Agassiz 35	0–80		x	x	x	
Alcyonium multiflorum Verrill	131–239					x
Alcyonium rubiforme (Ehrenberg)						
Anthomastus grandiflorus Verrill	150–300					x
Anthoptilum grandiflorum Verrill	1250					x
Anthothela grandiflora (Sars)	D.W.					x
Balticina finmarchica (Sars)	60–100				x	x
Bolocera tuediae (Johnston)	50–100				x	x
Ceratoisis ornata Verrill	200–300					x
Cerianthus borealis Verrill	28–200			x	x	x
Chondractinia nodosa (Fabricius)						
Cornulariella modesta Verrill	80–220				x	x
Cribrina stella (Verrill) 21	I.T.	x				
Desmophyllum nobile Verrill	300					x
Edwardsia farinacea Verrill	8–90		x	x	x	
Edwardsia sipunculoides Stimpson	0–4.		x			
Epigonactis fecunda Verrill	150–200					x

Bathymetric Tables—*Continued.*

	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms. 1–15	15–50	50–100	100 x
Alcyonaria—Con.						
Epizoanthus incrustatus (Duben & Koren)	30–300			x	x	x
Epizoanthus paguriphilus Verrill	D.W.					x
Eunepthya lutkeni (Marenzeller)	52				x	
Flabellum angulare Moseley	1250					x
Flabellum goodei Verrill	180–400					x
Funiculina armata Verrill	300–400					x
Lophohelia oculifera Edwards & Haime	D.W.					x
Metridium dianthus (Ellis) 35 = M. senile (Linn). 21.	o–90		x	x	x	
Paragorgia arborea (L)	D.W.					x
Paramuricea borealis Verrill	D.W.					x
Paramuricea grandis Verrill	D.W.					x
Peachia parasitica Verrill						
Pennatula aculeata Danielssen	60–300				z	x
Pennatula (Ptilella) borealis (Sars)	120–350					x
Primnoa reseda (Pallas)	100–200					x
Sagartia acanella Verrill	D.W.					x
Stomphia carneola (Stimpson) = Stomphia coccinea	8–35		x	x		
(O. F. Muller) Carlgren 21	10–12		x			
Synanthus mirabilis Verrill	150–330					x
Urticina crassicornis (Muller) = Urticina felina (L) Hadden 21	13–112		x	x	x	x
Virgularia lyungmani Kolliker	200					x
Ctenophora.						
Bolina alata Agassiz 36 = Berœ cucumis Fabricius, 16, 35	F.					
Idyia roseola L. Agassiz	F.			x		
Mertensia ovum (Fabricius) 16, 35	F.–25		x			
Pleurobrachia rhododactyla L. Agassiz 16, 35.	F.–5					
Echinodermata.						
Crinoidea.						
Antedon eschrichtii (Muller)	25–100			x	x	
Antedon quadrata P. H. Carpenter	25–100			x	x	
Antedon tenella (Retzius)						
Holothurioidea.						
Caudina arenata Stimpson 6, 35	o–17½		x	x		
Chirodota laevis (O. Fabricius)	o–5		x			
Eupyrgus scaber Lutken 6.	2–262		x	x	x	x
Lophothuria fabricii (Duben & Koren)	I.T.–5	x	x			
Myriotrochus rinkii Steenstrup	7–50		x	x		
Orcula barthii Troschel						
Pentacta calcigera Stimpson	8–25		x	x		
Pentacta frondosa (Jaeger)	o–7		x			
Pentacta minuta (Fabricius)	25–101			x	x	x
Psolus phantapus (L)	o–40		x	x		
Thyone scabra Verrill						
Thyonidium pellucidum (Fleming)						
Thyonidium productum (Ayres)	o–D.W.		x	x	x	x
Trochostoma ooliticum (Pourtales) = Molpadia oolitica Pourtales 6, 36	29			x		
Trochostoma turgidum (Verrill)						
Stelleroidea.						
Asterias enopla Verrill	53–100				x	
Asterias forbesii (Desor) 35	2–19		x	x		
Asterias polaris (Muller & Troschel)	o–60		x	x	x	
Asterias stellionura Perrier	82–100				x	
Asterias vulgaris (Stimpson) Verrill 35, 47	o–358		x	x	x	x
Cribrella pectinata Verrill	20			x		

BATHYMETRIC TABLES—*Continued.*

	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms. 1–15	15–50	50–100	100 x
Stelleroidea—Con.						
Cribrella sanguinolenta (Muller) = Henricia sanguinolenta 35, 47	o–471		x	x	x	x
Crossaster papposus (O. Fabricius)	o–179		x	x	x	x
Ctenodiscus crispatus (Retzius)	5–632		x	x	x	x
Hippasteria phrygiana (Parelius)	20–224			x	x	x
Leptasterias groenlandica (Lutken)	5–100		x	x	x	
Leptasterias littoralis (Stimpson)	I.T.–23	x	x	x		
Leptasterias tenera (Stimpson)	10–40		x	x		
Leptoptychaster arcticus (M. Sars)	100				x	
Lophaster furcifer (Duben & Koren.)	234–640					x
Odinia americana Verrill	175–400					x
Pedicellaster typicus M. Sars	75–80				x	
Pontaster hebitus Sladen	85–250				x	x
Pseudarchaster intermedius var. insignis Verrill	100–1356					x
Psilaster florae Verrill	60–230				x	x
Pteraster militaris (Muller)	10–69		x	x	x	
Pteraster pulvillus M. Sars	20			x		
Solaster earlii Verrill	170–300					x
Solaster endeca (Retzius)	o–80		x	x	x	
Solaster syrtensis Verrill	101					x
Stichaster albulus (Stimpson)	o–100		x	x	x	
Tosia eximia Verrill	80–122				x	x
Tosia granularis (Retzius)	40			x		
Tremaster mirabilis Verrill	150–250					x
Ophiuroidea.						
Amphipholis elegans (Leach)	o–210		x	x	x	x
Amphiura canadensis Verrill						
Amphiura exigua Verrill						
Amphiura sundevalli (Muller & Troschel)	10–15		x			
Astronyx loveni Muller & Troschel	85				x	
Gorgonocephalus agassizii (Stimpson) 35	o 100		x	x	x	
Gorgonocephalus eucnemis (Muller & Troschel)	18–80			x	x	
Gorgonocephalus lamarckii (Muller & Troschel)	194–239					x
Ophiacantha anomala G. O. Sars	101–131					x
Ophiacantha bidentata (Retzius)	o–250		x	x	x	x
Ophiacantha granulifera Verrill	101–200					x
Ophiacantha spectabilis G. O. Sars	131					x
Ophiacantha varispina Verrill	101–200					x
Ophiactis asperula (Phillipi) 37						
Ophioglypha lymani Ljungman 37						
Ophioglypha nodosa (Lutken)	o–330		x	x	x	x
Ophioglypha robusta (Ayres)	o–220		x	x	x	x
Ophioglypha sarsii (Lutken) 37	10–250		x	x	x	x
Ophioglypha signata Verrill						
Ophioglypha stuwitzi (Lutken)						
Ophiolebes acanella Verrill	113 122					x
Ophiopholis aculeata (L)	o 100		x	x	x	
Ophioscolex glacialis Muller & Troschel	210					x
Echinoidea.						
Echinarachnius parma (Lamarck)	1–100		x	x	x	
Schizaster fragilis (Duben & Koren)	95–300				x	x
Strongylocentrotus drobachiensis Muller 35, 47	o 110		x	x	x	x
PLATYHELMINTHES.						
Turbellaria (Planarians.)						
Fovia affinis (Oersted)						
Leptoplana ellipsoides Girard	o–45	....	x	x		
Procerodes ulvae (Oersted) 35	I.T.	x				
Typhlocolax acutus (Girard)	o–5	....	x			

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 x
NEMERTEA.						
Enopla.						
Amphiporus agilis Verrill	10-90.		x	x	x	
Amphiporus angulatus (Fabricius)	o–150...		x	x	x	x
Amphiporus heterosorus Verrill	10–200		x	x	x	x
Amphiporus lactifloreus (Johnston)	o...		x			
Amphiporus roseus (Muller)	o–112...		x	x	x	x
Amphiporus (?) superbus (Girard)	35			x		
Drepanophorus lankesteri Hubrecht	85				x	
Tetrastemma candidum (Fabricius?) M'Intosh	I.T.–15	x	x			
Tetrastemma serpentinum (Girard) Stimpson.	I.T.	x				
Tetrastemma vittatum Verrill	o–25..		x	x		
Anopla.						
Cephalothrix linearis (Rathke)	I.T.	x				
Cerebratulus cylindricus Packard						
Cerebratulus fuscus (Fabricius)	I.T.–20.	x	x	x		
Cerebratulus luridus Verrill						
Cerebratulus medullatus Hubrecht	85				x	
Cerebratulus melanops Coe & Kunkel 1						
Lineus sanguineus (Rathke)	I.T.	x				
Lineus socialis (Leidy)	I.T.	x				
Lineus truncatus (Hubrecht)?	75–80.				x	
Lineus viridis (Fabricius)	I.T.	x				
Micrura affinis (Girard)	o–100...		x	x	x	
Micrura rubra Verrill	40			x		
CHAETOPODA.						
Polychaeta.						
Ammotrypane aulogaster Rathke 12	100–125.					x
Ammotrypane cylindricaudatus Hansen 12						
Ammotrypane fimbriata Verrill, 35	7 90		x	x	x	
Ampharete gracilis Malmgren	10-90.		x	x	x	
Ampharete grubei Malmgren	4....		x			
Amphitrite cirrhata (Muller) Packard 35, 38, 44.	8–16		x	x		
Amphitrite groenlendica 38, 44						
Amphitrite intermedia Malmgren 17	76.......				x	
Antinoe sarsii Kinberg 12	60		..		x	
Aphrodita aculeata L. 35	10–106..		x	x	x	x
Arenicola piscatorum Lamarck = Arenicola marina (Linnaeus) 20, 35	I.T–20....	x	x	x		
Artacama canadensis McIntosh 38	30			x		
Artacama proboscoidea Malmgren 44	30–50....			x		
Axiothea catenata Malmgren = Axiothella catenata 33						
Brada granosa Stimpson	4–6..	....	x			
Brada granulata Malmgren 17	60 80			..	x	
Brada sublaevis Stimpson.						
Brada villosa Rathke 13						
Chaetozone setosa Malmgren 17	80				x	
Chaetozone setosa canadensis McIntosh 17						
Chaetozone whiteavesi McIntosh 17						
Chaetozone ? 17						
Chone duneri Malmgren 44						
Chone cf. fauveli McIntosh 44	5–20	....	x	x		
Chone infundibuliformis Kroyer 17	110–170..			.		x
Chone princei McIntosh 44.						
Chone sp. 17	20........	....	....	x		
Cirratulus cirrhatus (Fabricius) 17	17–40.....	....	x	x		
Cistenides granulata (L)	o–50.......	....	x	x		
Cistenides hyperborea Malmgren 38 = Pectinaria hyperborea 17	50–220....	....	....	.....	x	x

BATHYMETRIC TABLES—*Continued.*

	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms. 1–15	15–50	50–100	100 x
CHAETOPODA—*Con.*						
Polychaeta—Con.						
Clymenella torquata (Leidy)	o–60...		x	x	x	
Drilonereis canadensis McIntosh 2						
Enonella bicarinata Stimpson	o..		x			
Ephesia gracilis Rathke	125.					x
Ephesia sp. 13						
Ereutho smitti Malmgren 44	170					x
Eteone cylindrica OErsted	5		x			
Euchone lawrencii McIntosh 44						
Euchone rubrocincta 17						
Euchone tuberculosa (Kroyer) Malmgren 17	80				x	
Eumenia crassa OErsted	110–220..					x
Eunice oerstedii Stimpson	20–85....			x	x	
Eunice ? 2	200......					x
Eunoa nodosa (Sars)	45–60			x	x	
Eunoa oerstedi Malmgren 17, 35	17–76...		x	x	x	
Eunoa spinulosa Verrill						
Euphrosyne borealis OErsted	85				x	
Eupolynoe anticostiensis McIntosh 17	7–75..		x	x	x	
Eupolynoe occidentalis McIntosh	100.				x	
Eusyllis tubifex Gosse	51...				x	
Filograna filograna Berkeley 17	40			x		
Flabelligera affinis Sars 17	7–85		x	x	x	
Glycera dibranchiata Ehlers 3	100–120.					x
Glycera siphonostoma Delle Chiaje 3						
Goniada maculata OErsted 3						
Goniada norvegica Oersted 3	150...					x
Grymaea spiralis Verrill	60				x	
Harmothoe imbricata (L) 17, 35, 47	o–110...		x	x	x	x
Isocirrus ? sp. 33	125.......					x
Laenilla glabra Malmgren 17	7		x			
Laetmonice armata Verrill	50–150...				x	x
Laetmonice filicornis Kinberg 17	75...				x	
Laetmonice producta var. assimilis McIntosh	85				x	
Lagisca rarispina (Sars)						
Lagisca rarispina var. occidentalis M'Intosh						
Lanassa nordenskioldi Malmgren 38, 44						
Leaena abranchiata Malmgren 17	7		x			
Leanira tetragona OErsted	110–220.					x
Leanira yhleni ? Malmgren	210......					x
Leodice vivida (Stimpson)						
Lepidonotus squamatus (L) 17, 35, 47	I.T.–80.	x	x	x	x	
Lumbricoclymene sp. 17	45........			x		
Lumbriconereis cf. assimilis McIntosh 2	200					x
Lumbriconereis fragilis (Muller) 2, 17, 35	o–430..	x	x	x	x	x
Lumbrinereis hebes Verrill 17	5–80		x	x	x	
Maldane sarsii Malmgren 17, 33	20–30.....			x		
Malmgrenia whiteavesii M'Intosh	110–220...					x
Melinna cristata (Sars) 35	10–90.		x	x	x	
Myriochele heeri McIntosh 34						
Myxicola steenstrupi Kroyer 17	40...			x		
Naidonereis quadricuspida Blainville (*fide*, Verrill)						
Nemidia (?) canadensis M'Intosh						
Nemidia (?) lawrencii M'Intosh						
Nephthys caeca (Fabricius) 17, 47	3–80......		x	x	x	
Nephthys canadensis M'Intosh	56–80.				x	
Nephthys ciliata (Muller) 35	25–40....			x		
Nephthys incisa Malmgren 17, 35	2–430..		x	x	x	x
Nephthys lawrencii M'Intosh						
Nephthys longisetosa OErsted = Autolytus longisetosa 12	7.		x			
Nephthys picta Ehlers	30–80.			x	x	
Nereis abyssicola Stimpson	40.......			x		
Nereis denticulata Stimpson	o...		x			

BATHYMETRIC TABLES—*Continued.*

	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 x
CHAETOPODA—*Con.*						
Polychaeta—Con.						
Nereis iris Stimpson	20			x		
Nereis (Lycoris) pelagica L. 17, 35	o–106		x	x	x	x
Nereis virens Sars 35	o–10		x			
Nevaya whiteavesi McIntosh 24						
Nicolea zostericola (OErsted) Malmgren 17	7		x			
Nicomache canadensis McIntosh 33	175					x
Nicomache lumbricalis (Fabricius)	8–D.W.		x	x	x	x
Ninoe kinbergi Ehlers 2						
Nothria conchylega (Sars) 12 = Onuphis conchylega Sars 2, 35	7–125		x	x	x	x
Nychia amondseni Malmgren = Gattyana amondseni (Malmgren) McIntosh (17)	50–75				x	
Nychia cirrhosa (Pallas) = Gattyana cirrhosa (Pallas) McIntosh 12	7–80		x	x	x	
Onuphis cf. holobrachia Marenzeller 2	75–212				x	x
Onuphis sicula De Quatrefages	75–150				x	x
Onuphis quadricuspis Sars 2						
Ophelia glabra Stimpson	D.W.					x
Ophelia limacina Rathke	5		x			
Ophelia radiata Della Chiaje 12	10–12		x			
Owenia (or Ammocharis) filiformis Della Chiaje	110–220					x
Pholoe minuta (Fabricius)	8		x			
Pholoe tecta Stimpson	4		x			
Phyllodoce catenula Verrill						
Phyllodoce groenlandica OErsted	5–25		x	x		
Phyllodoce mucosa OErsted 17	30 60			x	x	
Phyllodoce sp. 17	80				x	
Pista cristata (O.F.Moller) 38, 44	75–210				x	x
Polycirrus sp. 38						
Polydara concharum Verrill.	10–100		x	x	x	
Polynoe gaspeensis M'Intosh	100–212					x
Potamilla neglecta Malmgren 17	45–75			x	x	
Potamilla oculifera (Leidy)	o–60		x	x	x	
Potamilla reniformis (O.F. Moller) 44						
Potamilla torelli Malmgren 34	85				x	
Praxilla gracilis Sars = Praxillella gracilis Sars 17, 33	7–112		x	x	x	x
Praxilla mulleri (Sars)	15–40			x		
Praxillella collaris (Claparede) 33						
Praxillella praetermissa (Malmgren) Verrill 33	7		x			
Praxillella sp. 17	50			x		
Prionospio steenstrupi Malmgren	45–220			x	x	x
Protula americana M'Intosh	85				x	
Protula media Stimpson	35–50			x		
Rhynchobolus capitatus (OErsted) = Glycera capitata 3, 35	o 17		x	x		
Sabella crassicornis Sars 17	75				x	
Sabella pavonina Savigny	125					x
Sabella penicillus (L) 44	220					x
Sabella zonalis Stimpson	4		x			
Sabellides borealis Sars 17, 31, 38	60				x	
Samthya sexcirrata Sars 17	30			x		
Scalibregma inflatum Rathke	D.W.					x
Scolecolepis cirrata (Sars) var.						
Scolopos armiger (O. F. Moller) 3, 17	45–80			x	x	
Scoloplos canadensis M'Intosh						
Siphonostomum asperum Stimpson	10–25		x	x		
Spinther citrinus (Stimpson)	35			x		
Spiochaetopterus typicus Sars 13,38	30–40			x		
Spirorbis borealis Daudin (?) = Spirorbis spirillum ??? 17	S.W.		x			
Spirorbis cancellatus (Fabricius) 17	7		x			
Spirorbis carinatus Montagu	D.W.					x

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms.			
			1–15	15–50	50–100	100 x
CHAETOPODA—*Con.*						
Polychaeta—Con.						
Spirorbis granulatus (Muller).........	10–50		x	x		
Spirorbis lucidus (Montagu).............	4–80		x	x	x	
Spirorbis quadrangularis Stimpson 35.	10–17	..	x	x		
Spirorbis spirillum Linnaeus 17, 35	I.T.–60	x	x	x	x	
Spirorbis stimpsoni Verrill......................	10–80		x	x	x	
Spirorbis validus Verrill 17	7–60		x	x	x	
Spirorbis vitreus (Fabricius)...................	20–30. .			x		
Sthenelais limicola Ehlers...........						
Tecturella flaccida Stimpson...............	3–15		x			
Terebella brunnea Stimpson	I.T.	x				
Terebella figulus Dalyell 38...................						
Terebellides stroemii M. Sars 17, 38, 43.	7 220		x	x	x	x
Thelepus cincinnatus (Fabricius) 17, 35, 38......	7–200		x	x	x	x
Thelepus cincinnatus var. canadensis M'Intosh...	51...				x	
Trichobranchus glacialis Malmgren 38...........						
Trophonia aspera Stimpson 17	7–80..		x	x	x	
Trophonia plumosa (Muller) = Stylarioides plumosa, Muller, 13..........................	8–125.	..	x	x	x	x
Vermilia serrula Stimpson......................	50		.	x		
GEPHYREA.						
Chaetifera.						
Sternaspis fossor Stimpson 17, 35, 47 .	2–90		x	x	x	
Achaeta.						
Phascolion alberti Sluiter 32..	700–900.					x
Phascolion strombi Montagu 32, 35 47...........	2–1061		x	x	x	x
Phascolion strombi canadensis Gerould 32...	33–206..			x	x	x
Phascolion strombi fusca Gerould 32.............	100–1000					x
Phascolion tubicola Verrill..........	85..				x	
Phascolosoma boreale Keferstein = P. margaritaceum (Sars) 32	30–75			x	x	
Phascolosoma caementarium (DeQuatrefages)...	2–90		x	x	x	
Phascolosoma hamulatum Packard..............	8		x			
Priapulus caudatus ? Lamarck..						
Priapulus pygmaeus Verrill......................	4–5		x			
BRACHIOPODA.						
Articulata.						
Hemithyris psittacea (Gmelin) 19	1–60...		x	x	x	
Terebratalia spitzbergensis (Davidson).........	20–120			x	x	x
Terebratella labradorensis (Sowerby)...........	1340				..	x
Terebratulina septentrionalis (Couthouy).........	12–220		x	x	x	x
POLYZOA.						
Cheilostomata.						
B ania admiranda Packard......................	50			x		
Becellaria ciliata (L) 28, 35....................	7–96		x	x	x	
Biowerbankia gracilis caudatus (Hincks) 28, 35......	40			x		
Bugula cucullifera Osburn 28, 35................	25.			x		
Bugula murrayana (Johnston) 28, 35............	7–110		x	x	x	x
Caberea ellisii (Fleming) 9, 28, 35........	6–100		x	x	x	
Cellepora avicularis Hincks....................	45			x		
Cellepora canaliculata Busk 28, 35...............	40–51.			x	x	
Cellepora contigua Smitt 28......................	45...		.....	x		
Cellepora pumicosa (L)...........						

BATHYMETRIC TABLES—*Continued.*

— —	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms.			
			1–15	15–50	50–100	100 x
POLYZOA—*Con.*						
Cheilostomata—Con.						
Cellularia peachii Busk 35	4–50		x	x		
Corynoporella tenuis Hincks						
Cribrilina annulata (Fabricius) 9, 28, 35	15–D.W.			x	x	x
Cribrilina punctata (Hassall) 9, 35, 47	1–50		x	x		
Electra catenularia (Jameson)						
Electra pilosa (L) = Membranipora pilosa 9	0–1		x			
Escharoides sarsii Smitt 28	10–60		x	x	x	
Flustra abyssicola G. O. Sars	220					x
Flustra borealis (Packard)	50			x		
Flustra carbasea Ellis & Solander 28	7–30		x	x		
Flustra membranaceo-truncata Smitt	56				x	
Flustra securifrons (Pallas) 28	30			x		
Flustra serrulata Busk 28	7–110		x	x	x	x
Flustra solida Stimpson	25–120			x	x	x
Gemellaria loricata (L) 9, 28, 35	0 110		x	x	x	x
Gemellaria loricata var. americana (Lamouroux)	10		x			
Hippothoa divaricata Lamouroux 35	18			x		
Hippothoa expansa Dawson						
Kinetoskias arborescens Danielssen 28	75–212				x	x
Kinetoskias smittii Danielssen	194					x
Lagenipora spinulosa Hincks						
Lepralia hippopus Smitt 28	25			x		
Lepralia (Discopora) megastoma Smitt						
Lepralia pertusa (Esper)	3–36		x	x		
Lepralia spathulifera Smitt 9, 28	30			x		
Membranipora craticula Alder 28, 35	7–38		x	x		
Membranipora cymbiformis Hincks	13–20		x	x		
Membranipora dumerilii Audouin)						
Membranipora flemingii Busk 28	1–20		x	x		
Membranipora lacroixii (Audouin)	30			x		
Membranipora lineata L. 9	10 50		x	x		
Membranipora monostachys Busk 47	1–6		x			
Membranipora sophiae Busk						
Membranipora sophiae var. armifera (Hincks)	56				x	
Membranipora spinifera Hincks 28	25 45			x		
Membranipora trifolium (Searles Wood) 28	25			x		
Membranipora unicornis Fleming 28, 35	8–25		x	x		
Membraniporella crassicosta Hincks 28	10–50		x	x		
Menipea ternata (Ellis & Solander) 9, 28, 35	6–110		x	x	x	x
Microporella ciliata (Pallas) 28, 35	8–25		x	x		
Monoporella spinulifera Hincks = Mucronella spinulifera 28	25			x		
Mucronella abyssicola (Norman)						
Mucronella pavonella (Alder)						
Mucronella peachii (Johnston) 35, 47	1–6		x			
Mucronella praelucida Hincks 28	25–60			x	x	
Mucronella ventricosa (Hassall) 28, 35	14–25		x	x		
Myriozoum coarctatum (Sars) 28	25–60			x	x	
Myriozoum planum (Dawson) = Schizoporella plana Dawson 28	25			x		
Myriozoum subgracile D'Orbigny	10–50		x	x		
Porella acutirostris Smitt 35						
Porella bella (Busk)						
Porella concinna (Busk) 9, 28, 35	10–60		x	x	x	
Porella elegantula (D'Orbigny)						
Porella elegantula var papposa Packard	45			x		
Porella laevis (Fleming)	56				x	
Porella minuta (Norman)						
Porella perpusilla Busk 28	80				x	
Porella proboscidea Hincks 28	20–38			x		
Porella propinqua Smitt						
Porella saccata Busk 28	25–110			x	x	x
Porella skenei (Ellis & Solander) 28	40–75			x	x	

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range. Min. and Max. Depth.	Inter-tidal Zone.	Fathoms. 1–15	15–50	50–100	100 x
POLYZOA—*Con.*						
Chilostomata—Con.						
Porella skenei var. plana Hincks	96				x	
Porella struma (Norman) 28	40–75			x	x	
Porella surcularis (Packard) = Cellepora surcularis 28	10–110		x	x	x	x
Porina tubulosa Norman 35	S.W.		x			
Ramphonotus minax (Busk)						
Retepora elongata Smitt	56–96				x	
Rhamphostomella bilaminata Hincks	38			x		
Rhamphostomella costata Lorenz 28	25–80			x	x	
Rhamphostomella ovata (Smitt) 28	25–45			x		
Rhamphostomella plicata Smitt						
Rhamphostomella radiatula (Hincks) 28	45			x		
Rhamphostomella scabra (Fabricius)						
Rhamphostomella scabra var. labiata (Stimpson)						
Schizoporella auriculata (Hassall) 28, 35	8–50		x	x		
Schizoporella biaperta (Michelin) 35, 47	1–56		x	x	x	
Schizoporella cincta Hincks (var.)						
Schizoporella cruenta (Norman)	56				x	
Schizoporella hyalina (L) 9 = Hippothoa hyalina, 28	30–313		x	x	x	x
Schizoporella linearis (Hassall)						
Schizoporella sinuosa (Busk) 9, 35						
Scruparia clavata Hincks 9						
Scrupocellaria americana Packard	6–30		x	x		
Scrupocellaria scabra (Van Beneden) 35						
Scrupocellaria scruposa (L)						
Smittia arctica Norman 35 = S. porifera 28	17–45			x		
Smittia candida (Stimpson)	35			x		
Smittia globifera (Packard)	30–45			x		
Smittia landsborovii (Johnston)						
Smittia producta (Packard)						
Smittia reticulatopunctata Hincks 28	45			x		
Smittia trispinosa (Johnston) 28, 35	25–45			x		
Umbonula verrucosa (Esper)						
Cyclostomata.						
Crisia denticulata (Lamarck) 28	10–45		x	x		
Crisia eburnea (L) 9, 28, 35	o–200		x	x	x	x
Crisia eburnea var. cribaria Stimpson = C. cribaria 28, 35	18–45			x		
Diastopora obelia Johnston	30–96			x	x	
Diastopora patina (Lamarck)	7		x			
Discofascigera lucernaria (Sars)	50–96				x	
Fasciporina flexuosa (Orbigny)						
Hornera lichenoides (L)	220					x
Idmonea atlantica (Forbes) Johnston 9 = Tubulipora atlantica 28, 35	40–45			x		
Idmonea serpens (L) 9	30			x		
Lichenopora clypeiformis (Orbigny)						
Lichenopora hispida (Fleming)	30–96			x	x	
Lichenopora regularis (Orbigny) 28	25			x		
Lichenopora verrucaria (Fabricius) 28, 35	7–60		x	x	x	
Stomatopora diastoporoides (Norman) 35						
Stomatopora granulata (Milne Edwards)	50			x		
Stomatopora penicillata (Fabricius)						
Tubulipora expansa (Packard)						
Tubulipora fimbria Lamarck	50			x		
Tubulipora flabellaris (Fabricius) 9, 28, 35	30			x		
Tubulipora lobulata Hassall						

BATHYMETRIC TABLES—*Continued.*

	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 x
Ctenosomata.						
Alcyonidium gelatinosum (L)	96				x	
Alcyonidium mytili Dalyell 35, 47	1–16		x	x		
Barentsia gracilis M. Sars						
Barentsia major Hincks 35	3–13		x			
Flustrella hispida (Fabricius)						
Pedicellina nutans Dalyell 9						
MOLLUSCA. *a*						
Pelecypoda.						
Anomia aculeata Muller 42	3–100		x	x	x	
Anomia simplex d'Orbigny 35, 46	2–8		x			
Arca (Bathyarca) glacialis Gray						
Arca (Bathyarca) pectunculoides Scacchi	70–430				x	x
Astarte banksii (Leach)	10–60		x	x	x	
Astarte banksii var. globosa Moller	70–80				x	
Astarte banksii var. striata Leach						
Astarte castanea Say 35, 42	5–20		x	x		
Astarte compressa (L)	10–50		x	x		
Astarte crebricostata Forbes	112–313					x
Astarte crenata Gray 46	15–120			x	x	x
Astarte lactea Broderip & Sowerby						
Astarte quadrans Gould 5	6–40		x	x		
Astarte subaequilatera Sowerby 42	50			x		
Astarte undata Gould 35, 42, 46	5–100		x	x	x	
Astarte undata var lutea Perkins	5–100		x	x	x	
Axinopsis orbiculata var. inaequalis Verrill & Bush.						
Cardium (Cerastoderma) ciliatum Fabricius 19, 35, 42	10–60					
Cardium (Laevicardium) mortoni Conrad 35	2–5					
Cardium (Cerastoderma) pinnulatum Conrad 35 42, 46	2–80		x	x	x	
Clidiophora gouldiana Dall 46 = Pandora gouldiana 35, 42	0–30		x	x		
Cochlodesma leanum (Conrad) 35	2–19					
Crenella decussata (Montagu)	20–60			x	x	
Crenella faba (Moller)	1–15		x			
Crenella glandula (Totten) 35, 42	0–60		x	x	x	
Crenella pectinula (Gould)						
Cryptodon (Axinulus) ferruginosus (Forbes).	200–313					x
Cryptodon gouldii Phillipi	10–313		x	x	x	x
Cryptodon (Axinulus) inaequalis Verrill & Bush	14–49		x	x		
Cryptodon obesus Verrill = Thyasira obesa 46.						
Cryptodon planus Verrill & Bush	8–100		x	x	x	
Cumingia tellinoides (Conrad)						
Cuspidaria arctica (M. Sars)	190 ?					x ?
Cuspidaria glacialis G. O. Sars	50–313				x	x
Cuspidaria pellucida (Stimpson)	40			x		
Cyprina islandica (L) 42	6–90		x	x	x	
Cyrtodaria siliqua (Daudin)	15–50			x		
Cytherea convexa Say 42, 46 = Callocardia morrhuana 35	I.T.–15	x	x			
Dacrydium vitreum (Moller)	100–313					x
Ensis directus (Conrad) = E. americanum Gould 35, 46	0–40		x	x		

a. NOTE.—Students of the geographic distribution of the Mollusca will find it instructive to compare with this list the following two papers by Dr. Wm. H. Dall:

"Checklist of the Recent Mollusks of the Northwest coast of America from the Polar sea to San Diego, California," pp. 1-44, 1916. S. West Museum, Los Angeles, Calif.

"Report on the Mollusca of the Arctic coast of America collected by the Canadian Arctic Expedition west from Bathurst Inlet." Scientific Results of the Expedition,—in the press.

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms.			
			1–15	15–50	50 100	100 x
MOLLUSCA—*Con.*						
Pelecypoda—Con.						
Epitonium groenlandicus Perry....................						
Kellia suborbicularis (Montagu)..						
Kennerlia glacialis (Leach) . .	15–50....			x		
Leda minuta (Muller)....	15–50....			x		
Leda pernula (Muller) 19......	50 59				x	
Leda pernula var. jacksonii Gould.....	10–20		x	x		
Leda tenuisulcata (Couthouy) 35.......	6–110		x	x	x	x
Limatula subauriculata (Montagu)..	38-313			x	x	x
Liocyma fluctuosa (Gould)...	10–50		x	x		
Lyonsia arenosa (Moller)..	15–60			x	x	
Lyonsia hyalina Conrad 35, 42, 46......	0–30...		x	x		
Macoma balthica (L) 42 = M. balthica fusca 35, 46	I.T. 6	x	x			
Macoma calcarea (Gmelin) 19, 46	3 80		x	x	x	
Macoma inflata Verrill & Bush	38 125			x	x	x
Megayoldia thraciaeformis (Storer) 42 = Yoldia thraciaeformis 35............................	10–200		x	x	x	x
Mesodesma deauratum (Turton)....						
Modiola (Brachydontes) demissa (Dillwyn) 35, 46	I.T.–7	x	x			
Modiola modiolus (L) 19, 35, 46..............	I.T.–25.	x	x	x		
Modiolaria corrugata (Stimpson) 35, 42..........	0–100...		x	x	x	
Modiolaria discors (L) 19, 42 46 = M. laevigata 35	0–100....		x	x	x	
Modiolaria nigra (Gray) 19, 35, 46..	I.T.-40	x	x	x		
Mulinia lateralis (Say) 35..............	4–10		x			
Mya arenaria L. 19, 35, 42, 46.	I.T.-40..	x	x	x		
Mya truncata L 19..	I.T.-45..	x	x	x		
Mytilus edulis L. 19, 35, 42, 46.	I.T.-19..	x	x	x		
Nucula delphinodonta Mighels 35, 42..	5½–100..		x	x	x	
Nucula expansa Reeve............................	30			x		
Nucula proxima Say 35, 46....................	1–17		x	x		
Nucula proxima var. trunculus Dall	4–80		x	x	x	
Nucula tenuis (Montagu) 19..................	4–100		x	x	x	
Ostrea virginica Gmelin 35...	<3 *a*....		x			
Panopaea (Panomya) norvegica Spengler.........	40–50			x		
Pecten gibbus var. borealis Say 35...............	2–15		x			
Pecten (Camptonectes) groenlandicus Sowerby..	200–313.					x
Pecten (Chlamys) islandicus Muller 19, 35...	1–100		x	x	x	x
Pecten (Placopecten) magellanicus (Gmelin) 19, 35, 42, 46	4–20		x	x		
Pecten (Cyclopecten) pustulosus Verrill	115 430					x
Pecten (Camptonectes) vitreus (Chemnitz)......	57–400				x	x
Periploma fragilis (Totten) 46..........	3–100....		x	x	x	
Petricola pholadiformis Lamarck 46........	I.T.-6...	x	x			
Portlandia glacialis (Wood)......................	15–25.		x	x		
Rochefortia molleri (Morch)....................	18........			x		
Saxicava rugosa (L) 42, 46 = S. arctica 19..	0–50...		x	x		
Serripes groenlandicus (Gmelin) 19.........	10–60		x	x	x	
Siliqua costata (Say) 35	17 ?...			x ?		
Siliqua squama (Blainville).....................						
Solenomya borealis Totten = Solemya borealis 35						
Solenomya velum Say = Solemya velum 35......	2–5		x			
Spisula (Hemimactra) polynyma (Stimpson)	0–10...		x			
Spisula (Hemimactra) solidissima (Dillwyn) 35, 46	0–19...	x	x	x		
Tellina (Angulus) tenera Say 35..............	0–19...		x	x		
Teredo dilatata Stimpson........						
Teredo navalis L. 35......	13–15.	x	x			
Thracia conradi Couthouy 35...........	6–19		x	x		
Thracia myopsis (Beck) Moller.....	10–50.		x	x		
Thracia truncata Mighels & Adams 42.	10–60		x	x	x	
Tottenia gemma (Totten) = Gemma gemma 35	I.T.–14..	x	x			
Turtonia minuta (Fabricius).......	0 ..		x			
Venericardia borealis (Conrad) 19, 35, 42, 46..	3–50	x	x			
Venus mercenaria L. 25.........................	0 6...		x			

a In Long Island Sound, the Oyster flourishes in 70 to 80 feet of water. J. L. Kellog, La. Gulf Biological Station Bull. No. 3. p. 11, 1905.

BATHYMETRIC TABLES—*Continued.*

	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 x
MOLLUSCA—Con.						
Pelecypoda—Con.						
Xylophaga dorsalis Turton						
Yoldia limatula (Say) 35, 46	2–30		x	x		
Yoldia myalis (Couthouy) 19	20			x		
Yoldia sapotilla (Gould) 35, 42	4–100		x	x	x	x
Yoldiella frigida (Torell)	100–313					x
Yoldiella lucida (Loven)	40–313			x	x	x
Zirfaea crispata L. 35	0–70		x	x	x	
Scaphopoda.						
Dentalium agile M. Sars						
Dentalium entalis L. 42	20–60			x	x	
Dentalium occidentale Stimpson	50–300				x	x
Siphonodentalium affine M. Sars	35			x		
Siphonodentalium lobatum (Sowerby)						
Gasteropoda.						
Acmaea rubella (Fabricius)	20–35			x		
Acmaea testudinalis (Muller) 19, 35, 42, 46	*a* I.T.	x				
Acrybia flava (Gould)	50			x		
Admete couthouyi (Jay) 19	10–60		x	x	x	
Æolis papillosa (L) = Aeolidia papillosa 35	I.T.–20	x	x	x		
Æolis purpurea Stimpson	I.T.	x				
Æolis stellata Stimpson	I.T.	x				
Alderia harvardiensis (Agassiz)	I.T.	x				
Alexia myosotis (Draparnaud) 35	I.T.	x				
Amaura candida Moller	20–50			x		
Amauropsis islandica (Gmelin)						
Amicula vestita (Boderip & Sowerby)						
Anachis haliaeti (Jeffreys)	67–96				x	
Ancula sulphurea Stimpson	I.T.	x				
Aporrhais occidentalis Beck 19, 42, 46	2–120		x	x	x	x
Astyris lunata (Say) 35	1–19		x	x		
Astyris rosacea (Gould) 35	8–60		x	x	x	
Astyris zonalis (Linsley) 35	8		x			
Bela angulosa Sars						
Bela bicarinata Couthouy	0–100		x	x	x	
Bela bicarinata var. violacea (Mighels & Adams)	0–100		x	x	x	
Bela cancellata (Mighels) 42	25			x		
Bela cancellata var. canadensis Verrill & Bush						
Bela concinnula Verrill	16–42			x		
Bela decussata (Couthouy) 42	10–100		x	x	x	
Bela exarata (Moller)	5–18		x	x		
Bela gouldii Verrill	16–41			x		
Bela harpularia (Couthouy) 35, 42	10–190		x	x	x	
Bela impressa Beck						
Bela incisula Verrill	5–110		x	x	x	x
Bela mitrula (Loven)	10–20		x	x		
Bela nobilis (Moller) 46	2–80		x	x	x	
Bela pingelii (Moller)	45			x		
Bela pleurotomaria (Couthouy) 35, 42	1–80		x	x	x	
Bela rosea Sars	2–57		x	x	x	
Bela sarsii Verrill	10–20		x	x		
Bela scalaris Moller 42	10–100		x	x	x	
Bela woodiana (Moller)	15			x		
Bittium nigrum Totten = B. alternatum 35	I.T.–5	x	x			
Buccinum ciliatum (Fabricius) 19	3–112		x	x	x	x
Buccinum cyaneum Bruguiere	45–100			x	x	
Buccinum cyaneum var. perdix (or finmarchianum) (Beck) Mörch 19						

a The young are dredged in 15 fathoms.

BATHYMETRIC TABLES—*Continued.*

—	Min. and Max. Depth.	Inter-tidal Zone.	Bathymetric Range. Fathoms. 1–15	15–50	50–100	100 x
Gasteropoda—Con.						
Buccinum cyaneum var. patulum Sars						
Buccinum donovani Gray 19	o–15		x			
Buccinum glaciale L.	I.T.	x				
Buccinum gouldii Verrill 19	60 ?				x ?	
Buccinum tenue Gray						
Buccinum tottenii Stimpson 19	*a* 8–15		x			
Buccinum undatum L. 19 = B. undulatum Muller 35, 42, 46	I.T.–170	x	x	x	x	x
Calliostoma occidentale (Mighels & Adams)	25–40			x		
Capulacmaea radiata M. Sars	150					x
Cerithiopsis costulata (Moller)						
Cerithiopsis greenii (Adams) 35	3–10		x			
Cerithiella whiteavesii Verrill	110 200					x
Chaetoderma nitidulum Loven	10–100		x	x	x	
Cingula (Onoba) aculeus Gould 35	I.T.	x				
Cingula arenaria Mighels & Adams	4–25		x	x		
Cingula (Alvania) areolata Stimpson	96				x	
Cingula carinata Mighels & Adams	96–200				x	x
Cingula (Alvania) castanea (Moller)	1–15		x			
Cingula globulus (Moller)	60 ?				x	
Cingula (Alvania) jan-meyeni (Friele)	20–200			x	x	x
Cingula minuta (Totten) 35	I.T.–1	x	x			
Cingula multilineata (Stimpson)						
Coryphella diversa (Couthouy) 19	4		x			
Coryphella mananensis (Stimpson) 35	20–90			x	x	
Coryphella stimpsoni Verrill	o–51		x	x	x	
Crenella decussata Montagu	20–60			x	x	
Crenella faba Fabricius 30						
Crenella glandula (Potten)	o–60		x	x	x	
Crenella pectinula (Gould)						
Crepidula convexa Say 35	I.T.–15	x	x			
Crepidula fornicata (L) 35, 46	I.T.–19	x	x	x		
Crepidula plana Say 35, 46	I.T.–45	x	x	x		
Crucibulum striatum (Say) 35, 42, 46	o–30		x	x		
Cylichna alba (Brown) 19, 35, 46	2–60		x	x	x	
Cylichna occulta (Mighels & Adams)						
Dendronotus arborescens Muller)19, 35	o 45		x	x		
Dendronotus robustus Verrill	I.T.–98	x	x	x	x	
Diaphana debilis (Gould)	6–50		x	x		
Diaphana hiemalis (Couthouy) 19	40			x		
Doris planulata Stimpson	I.T.	x				
Doto coronata (Gmelin) 35	15		x			
Doto formosa Verrill 35						
Eulima stenostoma Jeffreys						
Haminea solitaria (Say) 35	I.T.	x				
Hanleyia mendicaria (Mighels & Adams)	35–60			x	x	
Ianthina fragilis Lamarck 35						
Issa lacera (Muller)	90–92				x	
Lacuna glacialis Moller	96				x	
Lacuna neritoidea Gould						
Lacuna vincta (Montagu)	1–30		x	x		
Lepeta caeca (O. F. Muller) 19, 42	17–50			x	x	
Lepidopleurus alveolus M. Sars	220					
Lepidopleurus cancellatus Sowerby	95				x	
Liostomia eburnea (Stimpson)	25–70			x	x	
Litorina litorea (L) 19, 35, 42, 46	I.T.–6	x				
Litorina palliata (Say) 19, 35, 42, 46	I.T.	x				
Litorina rudis (Maton) 19, 35, 42	I.T.	x				
Lunatia groenlandica (Beck) Moller	3 60		x	x	x	
Lunatia heros (Say) 42, 46 = Polynices heros 35	I.T.–40	x	x	x		
Lunatia heros var. triseriata (Say) 46 = Polynices triseriata 35	I.T.–40	x	x	x		
Lunatia immaculata (Totten) = Polynices immaculata 35	o–25		x	x		

a The young are dredged in 21fathoms.

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 x
Gasteropoda—Con.						
Lunatia nana (Moller) = Polynices nana 35	45			x		
Margarita acuminata (Sowerby) Mighels & Adams	40			x		
Margarita cinerea Couthouy 19	10–60		x	x	x	
Margarita cinerea var grandis (Mörch) G. O. Sars. 42	10–60		x	x	x	
Margarita helicina (Fabricius) 19, 42	I.T.	x				
Margarita olivacea (Brown)	4–60		x	x	x	
Margarita umbilicalis Broderip & Sowerby						
Margarita undulata Sowerby 42 = Margarites undulatus 35	3–50		x	x		
Marsenina glabra (Couthouy	15		x			
Melampus bidentatus Say	I.T.	x				
Melampus lineatus Say 35, 46	I.T.	x				
Menestho albula (Fabricius)	2–15		x			
Menestho striatula (Couthouy) = Couthouyella striatula 15, 35	7–204		x	x	x	x
Molleria costulata (Moller)	4		x			
Nassa (Ilyanassa) obsoleta Say 35, 46	o–6		x			
Nassa (Tritia) trivittata Say 35, 46	I.T.–60	x	x	x	x	
Natica clausa Broderip & Sowerby 35, 42	19–110			x	x	x
Neptunea decemcostata (Say) 42, 46	o–45		x	x		
Neptunea despecta var. tornata Gould	10–60		x	x	x	
Odostomia bisuturalis (Say) 15, 35						
Odostomia fusca (Adams) 35	3–6		x			
Odostomia seminuda (Adams) 35	2–10		x			
Odostomia trifida (Totten) 35	o		x			
Odostomia (Menestho) trifida bedequensis Bartsch 15						
Odostomia (Chrysallida) willisi Bartsch 15						
Onchidoris muricata (Muller)	3–21		x	x		
Onchidoris pallida (Stimpson = Lamellidoris pallida 35	25			x		
Philine cingulata G. O. Sars	90				x	
Philine finmarchica M. Sars	90				x	
Philine fragilis G. O. Sars	90				x	
Philine lima (Brown) 19	10–15		x			
Philine quadrata (Searles Wood)	180–220					x
Polycera lessonii Orbigny	o–20		x	x		
Puncturella noachina (L) 42	I.T.–50	x	x	x		
Puncturella princeps Michels 30						
Purpura lapillus (L) 42 = Thais lapillus 35, 46	I.T.	x				
Ptychatractus ligatus (Mighels) 30	15–60			x	x	
Retusa gouldii (Couthouy)						
Retusa nitidula (Loven)	200					x
Retusa pertenuis (Mighels) 19, 42	8–10		x			
Scalaria (Acirsa) costulata (Mighels)						
Scalaria groenlandica Perry 42 = Boreoscala groenlandica 35	10–109		x	x	x	x
Scaphander punctostriatus (Mighels) 19	200					x
Scissurella crispata Fleming	4–790		x	x	x	x
Sipho ossiani (Friele)	180					x
Sipho pubescens Verrill)	88–91				x	
Sipho pygmaeus (Gould) 42	o–430		x	x	x	x
Sipho stimpsoni (Morch) 42	o–112		x	x	x	x
Sipho spitzbergensis (Reeve)	1–60		x	x	x	
Sipho ventricosus (Gray)						
Skeneia planorbis (Fabricius) 35	I.T.	x				
Solariella obscura (Couthouy)	10–60		x	x	x	
Solariella obscura var. bella	10 90		x	x	x	
Solariella varicosa (Mighels & Adams)	1–60		x	x	x	
Thais lapillus (L) 46	o–6		x			
Tonicella marmorea (Fabricius) 19, 42	o–50		x	x		
Tornatina canaliculata (Say) 35	3–5		x			
Trachydermon albus (L)	o–50		x	x		
Trachydermon ruber (L) 35 = Trachydermon rubrum 19	o–40		x	x		

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms. 1–15	15–50	50–100	100 x
Gasteropoda—Con.						
Trichotropis borealis Broderip & Sowerby 19	10–50		x	x		
Trichotropis conica (Beck) Moller 30						
Tritonofusus kroyeri (Moller) 19	3–60		x	x	x	
Tritonofusus latericeus (Moller)	20–357			x	x	x
Tritonofusus stimpsoni lirulatus Verril 35, 46	3–20		x	x		
Tritonofusus syrtensis (Packard)	30			x		
Trophon clathratus (L) 19	20–80			x	x	
Trophon clathratus var. gunneri Loven	16–60			x	x	
Trophon fabricii (Beck) Moller	38–50			x		
Trophon truncatus (Ström)	30			x		
Turbonilla (Pyrgiscus) hecuba Dall & Bartsch 30.	19			x		
Turbonilla interrupta var. fulvocincta (Totten)	2–10		x			
Turbonilla (Pyrgiscus) edwardensis Bartsch 15						
Turbonilla nivea Stimpson 35	40			x		
Turbonilla (Pyrgiscus) whiteavesi Bartsch 15						
Turritella erosa Couthouy 19	10–60		x	x	x	
Turritella reticulata Mighels & Adams 19	2–15		x			
Turritellopsis acicula (Stimpson) 19	o–50		x	x		
Urosalpinx cinerea (Say) 35, 46	1–15		x			
Velutella cryptospira Middendorf	57				x	
Velutina laevigata (Pennant) 35	o–17		x	x		
Velutina (Limneria) undata (Brown) 42	15		x			
Volumitra groenlandica Beck 7						
Volutopsis norvegica (Chemnitz)						
Pteropoda.						
Clione limacina (Phipps) 19, 35	F					
Limacina gouldii (Stimpson)	F					
Cephalopoda.						
Dibranchiata.						
Chiroteuthis lacertosa Verrill	F					
Gonatus fabricii (Lichtenstein)	F					
Histioteuthis collinsii Verrill	F					
Illex illecebrosus (Lesueur) 42 = Ommastrephes illecebrosa 35	F					
Ommastrephes megapterus (Verrill)	F					
Rossia hyatti Verrill	57–100				x	
Rossia sublevis Verrill	42–101			x	x	x
Rossia (?) tenera (Verrill)	85				x	
Octopoda.						
Octopus arcticus Prosch	60–101				x	x
Octopus lentus Verrill	120–602					x
Octopus obesus Verrill	160–300					x
Octopus piscatorum Verrill	120					x
Stauroteuthis syrtensis Verrill	250					x
CRUSTACEA.						
ENTOMOSTRACA						
Phyllopoda.						
Evadne nordmanni Loven 10, 11	F					
Evadne spinifera Linnaeus 11, 27	F					
Podon intermedius 11, 27	F					
Podon finmarchichus 27						
Podon leuckarti G. O. Sars 10						
Podon polyphemoides Lilljeborg 11, 27	F					

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms. 1–15	15–50	50–100	100 x
Cirripedia and Copepoda.						
Acartia clausi Giesbrecht 10, 36	F					
Acartia giesbrechti Dahl 10						
Anchorella sp. 31						
Argulus alosae Gould 10						
Argulus fundulus Kroyer 5, 35, 40	P					
Argulus sp. indet	P					
Balanus balanoides (L) 5, 18, 35, 45	I.T.	x				
Balanus crenatus Bruguiere 5, 18, 27, 35, 45	I.T.–30	x	x	x		
Balanus hameri Ascanius 5, 35, 45	I.T.–141	x	x	x	x	x
Balanus improvisus Darwin 45						
Balanus porcatus Da Costa 5, 18, 27, 35	10–150		x	x	x	x
Calanus finmarchichus Gunner 11, 27, 35	F					
Calanus helgolandicus Claus 10						
Caligus curtus Muller 35, 40	P					
Caligus rapax Milne Edwards 35, 40	P					
Centropages hamatus Lilljeborg 10, 11	F					
Centropages typicus Lilljeborg 11	F.					
Chondracanthus cornutus Muller 5, 40	P					
Chondracanthus merlucii Holten 5, 40	P					
Coronula diadema (L) 5, 18	P					
Coronula regina Darwin 45	P					
Dias longiremis Lilljeborg 27						
Euchaeta marina Pretandrea 10						
Eurytemora herdmani Thompson & Scott 10, 36	F					
Harpacticus chelifer Muller 11, 27, 35	F					
Irenaeus patersoni Templeton = Anomalocera patersoni 10	F					
Isias clavipes Boeck 10						
Labidocera aestiva Wheeler 10						
Lepas fascicularis Ellis & Solander 5 = L. fasciculatus 8, 35						
Lepas hillii Leach 5, 8, 35						
Lepeophtheirus salmonis Kroyer 18	P					
Lepeophtheirus hippoglossi Kroyer [a]	P					
Lernaea branchialis L. 5, 18, 40	P					
Microsetella atlantica Brady & Robertson	F					
Nemesis robusta 31	P					
Oithona plumifera Baird 11	F					
Oithona similis Claus 10						
Pandarus sinuatus Say 40	P					
Paracalanus parvus Claus 10						
Peltogaster paguri Rathke 18	3–6		x			
Pseudocalanus elongatus 10, 11	F					
Scalpellum pressum Pilsbry 8	224–330					x
Scalpellum stroemii Sars 5, 8	35–1000			x	x	x
Scalpellum velutinum Hock 27						
Temora sp. 27						
Tortanus discaudatus (Thompson & Scott) 10, 11, 22, 35, 36	F					
Ostracoda.						
Argilloecia sp						
Bradycinetus sp						
Bythocythere turgida Sars						
Cypridina excisa Stimpson 18	4–5		x			
Cythere abyssicola Sars				x		
Cythere badia ? Norman				x		
Cythere canadensis Brady 35				x		
Cythere concinna Jones 35				x		
Cythere costata Brady				x		
Cythere dawsoni Brady				x		

(*a*) From Skin of Hippoglossus vulgaris Flem. Le Have Island, E. Coast of Nova Scotia. C. H. Young, collector. Determined by Dr. C. B. Wilson.

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms.			
			1–15	15–50	50–100	100 x
Ostracoda—Con.						
Cythere dunelmensis Norman 35				x		
Cythere emarginata Sars 35				x		
Cythere leioderma Norman				x		
Cythere limicola Norman				x		
Cythere lutea Muller				x		
Cythere pellucida Band				x		
Cythere tuberculata Sars 35				x		
Cythere villosa Sars 35				x		
Cythere whitei Band				x		
Cytheridea (?) elongata Brady				x		
Cytheridea papillosa Bosquet				x		
Cytheridea punctillata Brady				x		
Cytheridea sorbyana Jones				x		
Cytherideis foveolata Brady				x		
Cytheropteron angulatum Br. & Rob				x		
Cytheropteron arcuatum Br. & Rob				x		
Cytheropteron nodosum Brady				x		
Cytheropteron vespertillo Reuss				x		
Cytherura (?) concentrica C. B. & R. (M. S.)				x		
Cytherura cristata Brady & Crosskey				x		
Cytherura (?) pumila C. B. & R. (M.S.)				x		
Cytherura sarsii Brady				x		
Cytherura (?) undata Sars (Var.)				x		
Eucythere argus Sars sp				x		
Krithe (Ilyobates) bartonensis Jones				x		
Loxoconcha sp				x		
Philomedes brenda Baird 14						
Philomedes interpuncta Baird				x		
Schlerochilus contortus Norman				x		
Xestoleberis depressa Sars 35				x		
MALACOSTRACA						
Leptostraca, and Arthrostraca.						
Acanthonotozoma serratum (Fabricius) 5, 18	5–50		x	x		
Acanthonotozoma inflatum (Kroyer) 18.	8		x			
Acanthostephia malmgreni Goes	70				x	
Acanthozone cuspidata (Lepechin) 5, 18, 27	5–80		x	x	x	
Aceros phyllonyx M. Sars	50–70			x	x	
Ǽga psora (L) 4, 5, 18	20–150			x	x	x
Ægina longicornis Kroyer 5	I.T.–32	x	x	x		
Ægina spinosissima (Stimpson) 5 = Æquiella spinossissima 27	10		x			
Amathilla homari (J. C. Fabricius) 18						
Ampelisca eschrichtii Kroyer 18	14–110		x	x	x	x
Ampelisca macrocephala Lilljeborg 5, 18, 35	8–50		x	x		
Ampelisca typica Spence Bate						
Amphithoe podoceroides Rathke	o–8		x			
Apmhithoe punctata Say	4		x			
Amphithoe rubricata Montagu 18, 27	8		x			
Anonyx exiguus Stimpson	8–15		x			
Anonyx nugax (Phipps) 18, 35	I.T.–40	x	x	x		
Anonyx pallidus Stimpson	4–20		x	x		
Anonyx politus Stimpson	40			x		
Anonyx pumilus Lilljeborg	10–15		x			
Apherusa bispinosa 18	10–20		x	x		
Arcturus baffini Westwood 18						
Astacilla granulata (G. O. Sars) 4, 5	7–640		x	x	x	x
Byblis gaimardii (Kroyer) 5, 18	10–60		x	x	x	
Calathura brachiata (Stimpson) 4, 35	10–250		x	x	x	x
Calliopius laeviusculus (Kroyer) 5, 18	F.					
Caprella linearis (L) 5, 18, 27	4–32		x	x		
Caprella longimanus Stimpson						

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms.			
			1–15	15–50	50–100	100 x
MALACOSTRACA—*Con.*						
Leptostraca and Arthrostraca—Con.						
Caprella sanguinea Gould						
Caprella stimpsonii Spence Bate = C. robusta 27	12		x			
Centromedon pumilus 18	15		x			
Chiridotea coeca (Say) 4, 5, 35	I.T.	x				
Chiridotea tuftsii (Stimpson) 4, 5	o		x			
Cirolana borealis Lillejborg 4	30–300			x	x	x
Cirolana concharum Stimpson 4	o–18		x	x		
Cirolana polita Stimpson 4, 5	I.T.–150	x	x	x	x	x
Dajus mysidis Kroyer 4, 18						
Dulichia porrecta Spence Bate 18						
Epelys montosus (Stimpson) = Edotea montosa 4, 5, 35	14–40		x	x		
Epimeria loricata G. O. Sars 5	85–212				x	x
Ericthonius difformis Milne-Edwards 8 = E. rubricornis 27	8–100		x	x	x	
Eurycope robusta Harger = Eurycope cornuta Sars 4	50–400				x	x
Eusirus cuspidatus Kroyer						
Euthemisto bispinosa (Boeck) 5, 35	F.					
Euthemisto compressa Goes. 11	F.					
Euthemisto libellula (Mandt.) 18	F.					
Gammaracanthus macrophthalmus (Stimpson)	o		x			
Gammarus locusta (L ?) J. C. Fabricius 18, 27	I.T.–21	x	x	x		
Gnathia cerina (Stimpson) 5, 18	10–220		x	x	x	x
Gyge hippolytes (Kroyer) = Bopyroides hippolytes 4	5–70		x	x	x	
Halirages bispinosus (Spence Bate)						
Halirages fulvocinctus (M. Sars) 5, 18	10–220		x	x	x	x
Haploops setosa Boeck 5	30–110		x	x	x	
Haploops tubicola Lilljeborg 5, 18	15–106		x	x	x	
Harpinia fusiformis (Stimpson)	20–220			x	x	x
Hyale littoralis (Stimpson) = Allorchestes littoralis 5, 35	I.T.	x				
Hyperoche medusarum (Kroyer) = Hyperia medusarum 18, 35	F.					
Idotea marina (L) 5 = Idothea baltica 35	I.T.–30	x	x	x		
Idotea phosphorea Harger 4, 27, 35	I.T.–30	x	x	x		
Idotea robusta Kroyer = Idothea metallica 35, 45	0–91		x	x	x	
Jaera albifrons Leach = Jaera marina, 4, 18, 35	I.T.	x				
Janira alta (Stimpson) 4, 5	I.T.–487	x	x	x	x	x
Janira spinosa Harger = Tobella spinosa 4						
Lafystus sturionis Kroyer 5, 35						
Leptocheirus pinguis (Stimpson) 47 = Ptilocheirus pinguis, 5, 27	0–150		x	x	x	x
Leptochelia filum (Stimpson) 4, 18	8–20		x	x		
Leucothoe grandimanus Stimpson	30			x		
Limnoria lignorum (Rathke) 4, 35	1–3		x			
Lysianax spinifera (Stimpson)	40			x		
Lysianopsis alba Holmes 5, 18, 27	4–13		x			
Maera danae (Stimpson) 5	50			x		
Maera sp	22–30			x		
Mayerella limicola Huntsman 41	5–50		x	x		
Melita dentata (Kroyer) 5, 18, 27	$7\frac{1}{2}$ 430		x	x	x	x
Melita goesii Hansen	70				x	
Melphidippa sp. indet	14–220		x	x	x	x
Metopa glacialis (Kroyer)						
Mesidotea entomon Linn 18						
Mesidotea sabinii Kroyer 18						
Metopa groenlandica Hansen 5, 27	86–150				x	x
Monoculodes borealis Boeck	20			x		
Monoculodes demissus Stimpson	4		x			
Monoculodes sp. indet	60				x	
Munna fabricii Kroyer 4	4–200		x	x	x	x

Bathymetric Tables—*Continued.*

—	Bathymetric Range. Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms. 1–15	15–50	50–100	100 x
Malacostraca—*Con.*						
Leptostraca and Arthrostraca—Con.						
Munnopsis typica M. Sars 4, 18	5–400		x	x	x	x
Nebalia bipes (Fabricius) 18	4–220		x	x	x	x
Oediceros lynceus M. Sars = Paroediceros lynceus 5, 18	4–85		x	x	x	
Oediceros saginatus Kroyer						
Onisimus edwardsii Kroyer 18						
Orchestia agilis S. I. Smith 5, 27, 35	I.T.					
Orchestia gryllus Gould	I.T.	x				
Orchomene minutus (Kroyer) = Orchomenella minuta 18	10–15		x			
Paramphithoe cataphracta (Stimpson)	4–50		x	x		
Paramphithoe pulchella (Kroyer) 5, 27	25–90			x	x	
Parathemisto oblivia (Kroyer)	F.					
Pardalisca cuspidata Kroyer 5	35–70			x	x	
Phoxocephalus holbolli (Kroyer) 5, 18, 35	0–200		x	x	x	x
Phryxus abdominalis (Kroyer) 4, 18, 35	5–351		x	x	x	x
Pleustes bicuspis (Kroyer) = Paramphithoe bicuspis 18						
Pleustes panoplus (Kroyer) 5, 18	4–85		x	x	x	
Podocerus fucicola (Stimpson)						
Podocerus nitidus (Stimpson) = Podoceropsis nitidus 5	30–60			x	x	
Pontogeneia inermis (Kroyer) 5, 18, 35	I.T.–15	x	x	x		
Pontoporeia femorata Kroyer 5, 18	1–60		x	x	x	
Ptilanthura tenuis Harger 4, 35	0–19		x	x		
Rhacotropis aculeatus (Lepechin) 5, 18	10–122	x	x	x	x	x
Socarnes vahli Kroyer 18						
Stegocephalus inflatus Kroyer 5, 18, 35	50–150				x	x
Stenothoe clypeata Stimpson	30			x		
Synidotea bicuspida (Owen) = S. marmorata 4, 18	12–129		x	x	x	x
Synidotea nodulosa (Kroyer) 45	6–190		x	x	x	x
Syrrhoe crenulata Goes 5	12–100		x	x	x	
Tiron acanthurus Lilljeborg	45			x		
Tryphosa horringii Boeck 18						
Unciola irrorata Say 5, 18, 27, 35	0–430		x	x	x	x
Cumacea.						
Diastylis goodsiri (Bell) 25	60–218				x	x
Diastylis luciferus (Kroyer) 5	10–77		x	x	x	
Diastylis politus S. I. Smith 5, 25, 35	7–190		x	x	x	x
Diastylis quadrispinosus G. O. Sars 5, 18, 25, 35	2–190		x	x	x	x
Diastylis rathkii (Kroyer) 18, 25	3–499		x	x	x	x
Diastylis scorpioides (Lepechin) 25	13–206		x	x	x	x
Diastylis sculptus G. O. Sars 5, 25, 35	0–190		x	x	x	x
Diastylopsis ? resima (Kroyer) 25	57				x	
Eudorella emarginata (Kroyer)	30–52			x	x	
Eudorella hispida G. O. Sars 35	1–4		x			
Eudorella integra S. I. Smith = Eudorellopsis integra 25	29–110			x	x	x
Eudorella pusilla G. O. Sars	1–15		x			
Lamprops quadriplicata (S. I. Smith) 5, 25	7–37		x	x		
Leucon nasicoides Lilljeborg 5	42–110			x	x	x
Leucon nasicus Kroyer	50–70				x	
Petalosarsia declivis (G. O. Sars) 25	39–89			x	x	
Schizopoda.						
Meterythrops robusta S. I. Smith = Parerythrops robusta 5	33–70			x	x	
Mysis mixta Lillejeborg 5, 18	20–90			x	x	
Mysis oculata (Fabricius)	F.					
Mysis stenolepis S. I. Smith = Michtheimysis stenolepis 35	16–21			x		
Nyctiphanes norvegica (M. Sars) 5 = Meganyctiphanes norvegica 35, 39	F.					

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms. 1–15	15–50	50–100	100 x
Decapoda.—Macrura.						
Pseudomma roseum G. O. Sars	110–210					x
Pseudomma truncatum S. O. Smith	45–70			x	x	
Rhoda inermis (Kroyer) 5 = Thysanoessa inermis 35	40–220			x	x	x
Thysanoessa (Rhoda) inermis neglecta (Kroyer) 39	300					x
Thysanoessa raschii M. Sars 39	0–300		x	x	x	x
Calocaris mcandreae Bell	190					x
Caridion gordoni (Spence Bate) 5	27–110			x	x	x
Crangon vulgaris J. C. Fabricius 27 = Crago septemspinosus 18, 35	0-50		x	x		
Eupagurus bernhardus (L) = Pagurus acadianus Benedict 5, 27, 35, 47	0–150		x	x	x	x
Eupagurus kroyeri Stimpson = Pagurus kroyeri 5, 18, 35	0–306		x	x	x	x
Eupagurus pubescens (Kroyer) 47 = Pagurus pubescens 5, 18, 35	0–150		x	x	x	x
Hetairus debilis Spence Bate	85				x	
Hetairus tenuis Spence Bate	85				x	
Hippolyte fabricii Kroyer 27 = Spirontocaris fabricii 5, 18	0–125		x	x	x	x
Hippolyte macilenta Kroyer = Spirontocaris macilenta 18	15–75		x	x		
Hippolyte projecta Spence Bate	85				x	
Homarus americanus Milne Edwards 5, 18, 27, 35	0–20		x	x		
Lithodes maia (L) 5	250–291					x
Munidopsis curvirostra Whiteaves	35–1290			x	x	x
Nectocrangon dentatus Rathbun 18						
Nectocrangon lar (Owen)	10–60		x	x	x	
Pagurus irroratus Linnaeus 27						
Pagurus longicarpus Say 5, 35, 47	I.T.–18	x	x	x		
Pandalus borealis Kroyer 5	40–160			x	x	x
Pandalus leptocerus Smith 5	S.W.–630		x	x	x	x
Pandalus montagui Leach 5, 18, 27, 35	6–430		x	x	x	x
Parapagurus pilosimanus S. I. Smith	353–2021					x
Pontophilus norvegicus M. Sars 5	92–115			x	x	x
Sabinea sarsii S. I. Smith 5	16–150				x	x
Sabinea septemcarinata (Sabine) 5, 18	15–85			x	x	
Sclerocrangon boreas (Phipps) 5, 18	o-36		x	x		
Spirontocaris gaimardii (Milne Edwards) 5, 18	o-60		x	x	x	
Spirontocaris gaimardii var. belcheri Bell. 18	8–75		x	x	x	
Spirontocaris groenlandica (J. C. Fabricius 5 = Hippolyte groenlandica 18, 27, 35	1–72		x	x	x	
Spirontocaris polaris (Sabine) 5 = Hippolyte polaris, 18, 27	3–218		x	x	x	x
Spirontocaris pusiola (Kroyer) 5, 35	o-125		x	x	x	x
Spirontocaris spinus (Sowerby) = Hippolyte spinus 5, 18, 27	5–90		x	x	x	
Spirontocaris stoneyi Rathbun 18	7		x			
Spirontocaris turgida (Kroyer) = Hippolyte phippsi 5	7–125		x	x	x	x
Decapoda—Brachyura.						
Cancer amaenus Herbst 1= C. irroratus Say 18, 27, 35, 47	I.T.–19	x	x	x		
Cancer borealis Stimpson 5	I.T.–21	x	x	x		
Chionoecetes opilio (O. Fabricius) 5, 18	10–101		x	x	x	x
Hyas araneus (L) 18, 27	o-106		x	x	x	x
Hyas coarctatus Leach 5, 18, 35, 47	o-106		x	x	x	x
Libinia emarginata Leach 5, 35, 47	I.T.–19	x	x	x		
Neptunus sayi Milne Edwards	85				x	

BATHYMETRIC TABLES—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal Zone.	Fathoms.			
			1-15	15-50	50-100	100 x
ARACHNIDA.						
Pycnogonida.						
Achelia spinosa (Stimpson)						
Ammothea achelioides Wilson					x	
Nymphon brevicollum Hoek	85				x	
Nymphon grossipes (O. Fabricius) 35	12–110		x	x		x
Nymphon hirtum J. C. Fabricius	o–50		x	x		
Nymphon longitarse Kroyer	16–90			x	x	
Nymphon macrum Wilson						
Nymphon stroemii Kroyer	35–110			x	x	x
Phoxichilidium maxillare (Stimpson)	I.T.–55	x	x	x	x	
Pseudopallene hispida (Stimpson)	50–55				x	
Pycnogonum littorale (Strom)	I.T.–430	x	x	x	x	x
CHORDATA.						
Amaroucium glabrum Verrill 23, 26, 35	o–80		x	x	x	
Amaroucium pallidum Verrill = Aplidium pallidum 23, 35	o–471		x	x	x	x
Aplidium despectum Herdman	51				x	
Ascidia complanata Fabricius = Phallusia prunum 29 = Ascidiopsis prunum 26	I.T.-150	x	x	x	x	x
Ascidia falcigera Herdman	85				x	
Boltenia bolteni (L) 30	30–56			x	x	
Boltenia bolteni (L) var. rubra = Pyura ovifera 29	30–56			x	x	
Boltenia ciliata Moller = Pyura ovifera 29	30			x		
Boltenia elegans Herdman = Pyura ovifera 29 and Boltenia ovifera 26, 47	51				x	
Botrylloides aureum Sars 23, 26	S.W.-160		x	x	x	x
Botryllus (spec. undet.)	50–96				x	
Caesira canadensis 26	I.T.	x				
Caesira intumescens Van Name 29	39			x		
Caesira septentrionalis Traustedt 29	50			x		
Chelyosoma geometricum Stimpson = C, macleayanum 26, 29	6–54		x	x	x	
Ciona tenella (Stimpson) = C, intestinalis (L) 29	5–127		x	x	x	x
Dendrodoa aggregata pulchella Verrill 29	10–40		x	x		
Dendrodoa carnea Agassiz 26, 29 = Cynthia carnea 35	S.W.–39		x	x		
Dendrodoa grossularia Van Beneden 29	45			x		
Didemnopsis tenerum (Verrill) 23, 26	10–76		x	x	x	
Eugyra glutinans (Moller) 35	6		x			
Eugyra pilularis Verrill 35 = Bostrichobranchus pilularis 29	½–120		x	x	x	x
Glandula arenicola Verrill = Tethyum molle 29	10–150		x	x	x	x
Glandula fibrosa Stimpson = Pandocia fibrosa 29	30–238			x	x	x
Glandula mollis Stimpson = Tethyum molle 29	10–150		x	x	x	x
Halocynthia echinata (L) 35 = Pyura echinata 29 and Boltenia hirsuta 26	o–120		x	x	x	x
Halocynthia pyriformis (Rathke) = Pyura aurantium 29 and Tethyum pyriforme americanum	o–120		x	x	x	x
Halocynthia rustica (L) = Tethyum rusticum 29	8		x			
Halocynthia tuberculum (Fabricius) = Tethyum coriaceum Alder & Hancock 29	10–225		x	x	x	x
Holozoa clavata (Sars) 26,29 ?	S.W.-150		x	x	x	x
Leptoclinum albidum Verrill = Tetradidemnum albidum 23, 26	o–110		x	x	x	x
Leptoclinum albidum var. luteolum = Tetradidemnum albidum 29	o–110		x	x	x	x
Leptoclinides faeroensis Bjerkan 23	100–1582					x
Lissoclinum aureum Verrill 23, 26	S.W.–100		x	x	x	x
Macroclinum pomun Sars 23	75				x	
Microcosmus nacreus Van Name 29	26–36			x		
Molgula littoralis, Verrill = Caesira citrina 29 & Caesira littoralis 26	I.T.–126	x	x	x	x	x

Bathymetric Tables—*Continued.*

—	Bathymetric Range.					
	Min. and Max. Depth.	Inter-tidal. Zone.	Fathoms.			
			1–15	15–50	50–100	100 x
Chordata—*Con.*						
Molgula pannosa Verrill 35 = Caesira pannosa 26, 29	10–80		x	x	x	
Molgula papillosa Verrill 35 = Caesira papillosa 26, 29	10–100		x	x	x	
Molgula producta Stimpson 35 = Caesira producta 29	I.T.–29	x	x	x		
Molgula retortiformis Verrill = Caesira retortiformis 26, 29	10–125		x	x	x	x
Pera crystallina (Moller) = Caesira crystallina 29	10–30		x	x		
Pelonaia arenifera Stimpson = P. corrugata 26, 29	15		x			
Phallusia obliqua (Alder) 29 = Phallusioides obliqua 26	33–320			x	x	x
Polycitor kukenthali (Gottschaldt) 23	8–225		x	x	x	x
Tethyum finmarkense Kiaer 29	11–67		x	x	x	
Tethyum mortenseni Hartmeyer 29	45–350			x	x	x

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XV

HYDROGRAPHY IN PASSAMAQUODDY BAY AND VICINITY, NEW BRUNSWICK.

(By Professor Alexander Vachon, B.A., L.Ph., etc., Laval University, Quebec.)

The laws that regulate the distribution of the plankton in the sea furnish a problem of paramount importance in the progressive industry of fisheries. Qualitative and quantitative determinations of the plankton are made at selected hydrographic stations, since the plankton is followed by multitudes of fishes which live on it, and those fishes are followed by others which serve as food for men.

As the plankton, which regulates, to a great extent, the migrations of the fish, is itself at the mercy of the chemical, physical and mechanical conditions of the sea, it is easily understood of what economical importance a correct knowledge of those conditions will prove. We speak of the migrations of the herrings and sardines; they are the same as those of the plankton which serve as food for them, and the presence of the plankton is ruled by depth, light, temperature, salinity, pressure and density.

TEMPERATURE.

The heat of the atmosphere, emanating from the sun, penetrates the water, and is attenuated according as the depth increases. At the surface, the temperature of the water is almost as changeable as that of the air adjoining it, the variations of which find their repercussion in the contiguous liquid, although somewhat mitigated. Cold in winter, warmer in summer, the surface water expresses the alterations in the temperature of the air. Therefore, in summer, the sun's rays heat the water at the surface, and to a depth of a few meters. The difference between the temperature of the day and that of the night ceases to be perceptible at a small depth; in order to find the region which is insensible to summer and winter variations, we must go down further. At about one thousand metres, the secular variations are imperceptible. Then begins the zone where the temperature never varies; by a slow and regular progression, the temperature grows colder and colder until it is only about one or two degrees above zero. This low temperature is found even in the tropical regions, where the scorching rays of the sun beam constantly upon the surface.

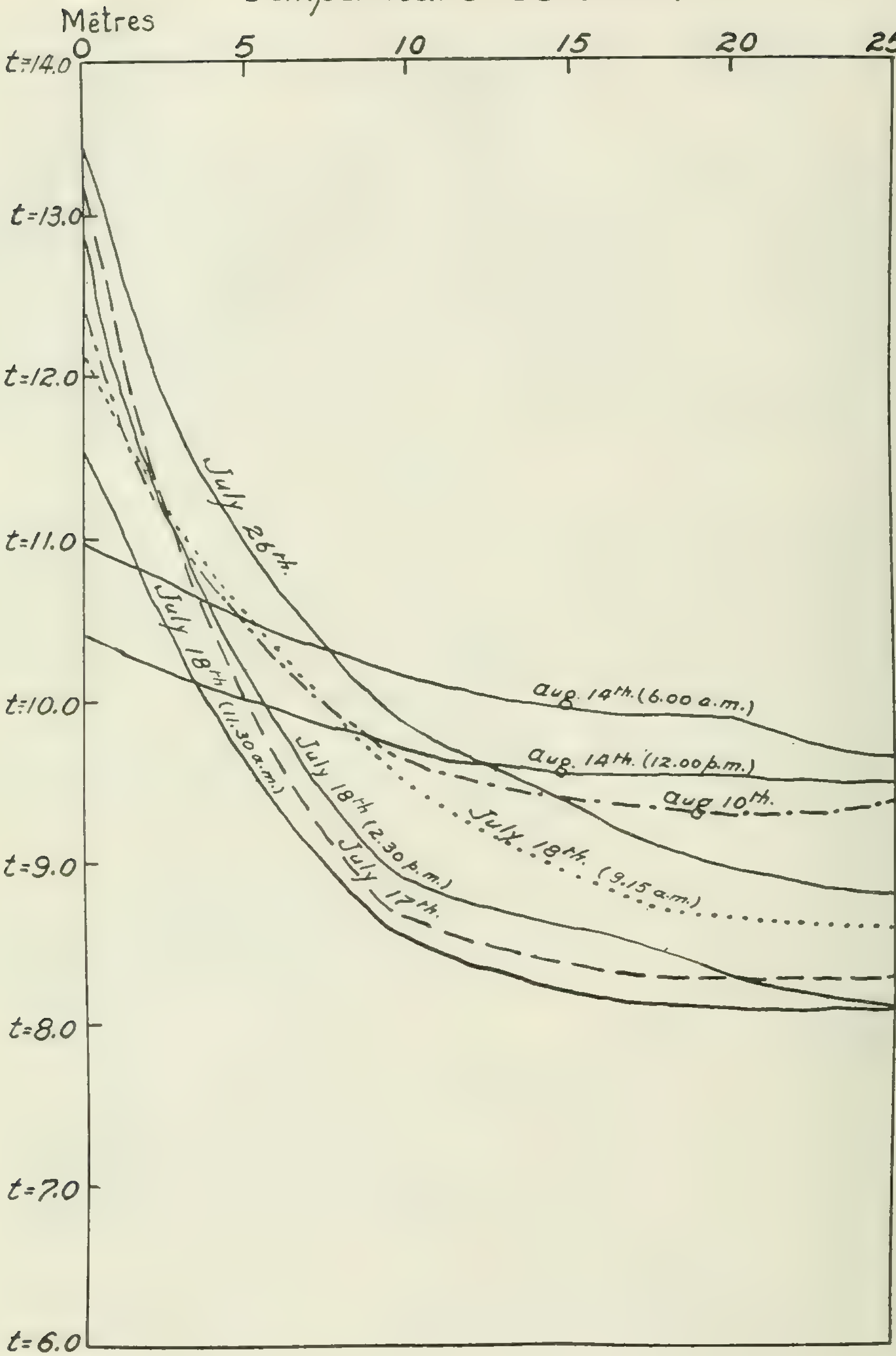
Ordinarily, the water gradually becomes cooler from the surface to the bottom, because, apart from the effect of the sun's heat at the top, cold water is more dense and goes to the bottom; but, in the polar regions, and where there are cold currents, we sometimes find an area of colder water between two warmer regions, and this state of unstable equilibrium, where the water is cooler, more salt and more dense, affords very interesting information.

Light does not penetrate into the water further than two or three hundred metres from the surface, hence, no green plants are found at such depths, as light is necessary for the decomposition of carbon dioxide which is the bread of the vegetable kingdom.

When water is heated, it goes to the surface; if it be concentrated, it seeks a lower level; should it cool for some reason or other, by the atmosphere or by evaporation, it also descends. Everything influences the temperature of the superficial water, the cold, polar currents as well as the hot currents coming from the equatorial regions.

We understand why it is that the water is so cold at the bottom of the ocean, since cold water descends, and being free from the heating influence of the sun in those depths, where the light of day never reaches, and, on account of the feeble power of water to conduct heat, the temperature of the lower regions of the ocean never varies. Kelvin and Wegemann made calculations concerning the conduction of heat through water and came to the conclusion that this conduction is practically negligible. With a temperature of 30° C. at the surface and the water perfectly still, it would take one hundred years for any heat to be perceived at a depth of a hundred

Temperature Sections.



metres. Therefore, in practice, heat propagates through the water only by the movements of the waves and currents.

Looking over our records one can see that at the same depths in different stations, the temperature gradually becomes higher as the season advances, and in the month of July, at *Prince* station 5, we found a temperature of 4°.9 C. at 100 fathoms or 182 metres.

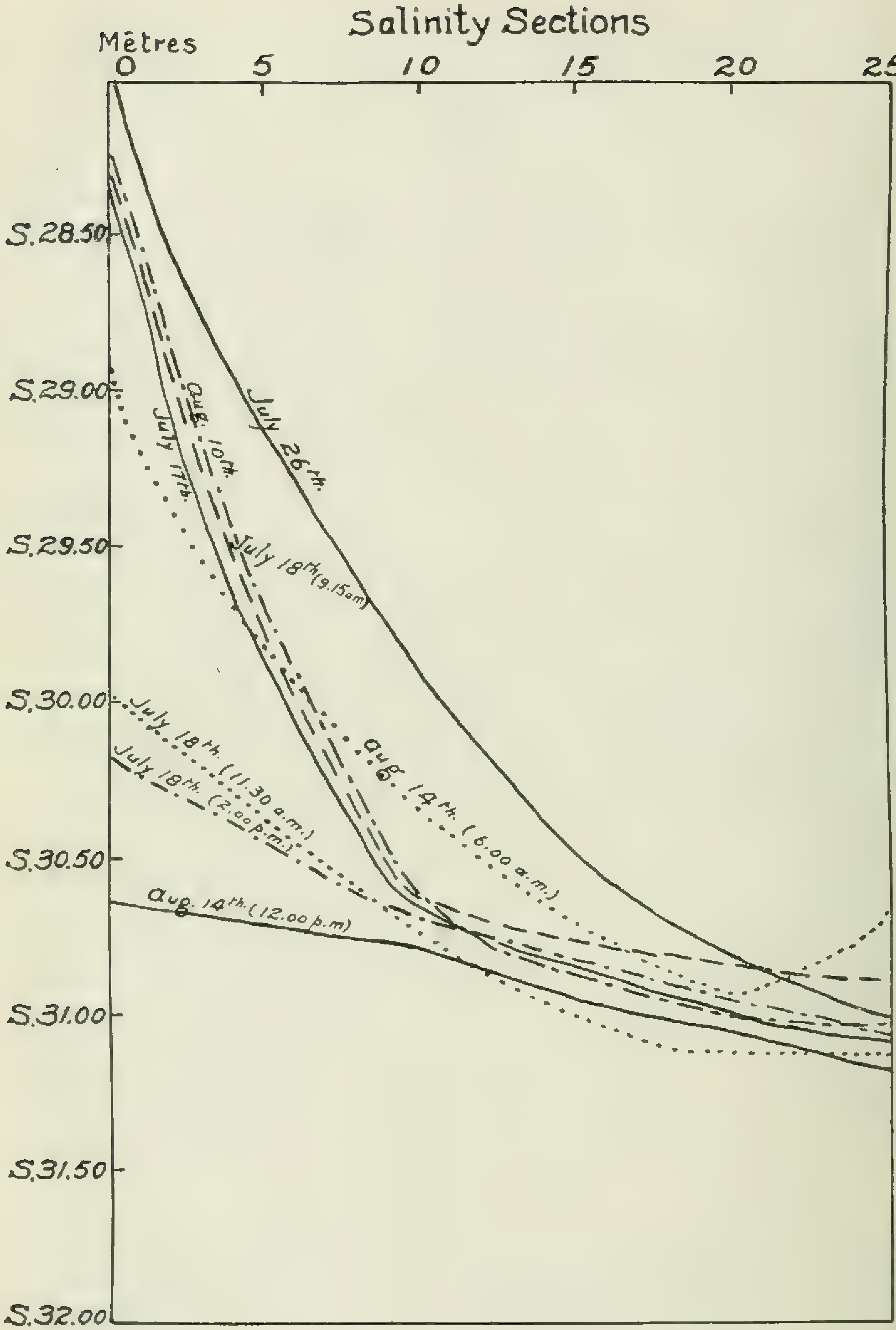
It is an easy matter to find out the temperature of the air or of the surface water; the thermometer can be read directly as soon as the expansion or contraction of the liquid in the tube is in equilibrium with its surroundings. However, it is not thus when one has to measure the exact temperature of a layer of water situated at a depth of a few hundred or thousand feet. Between the surface and the deep layer to be examined, there may be and, as a matter of fact, there are other layers that are colder or warmer. Even if the thermometer is sent down and left long enough to indicate the temperature of the water at a measured depth, when it is brought up to be read, the mercurial column, by going through regions of different temperatures, will change in length; it will contract, if it meets colder water and will expand if it comes in contact with warmer regions, it is impossible, therefore, to thus get the temperature of the lower regions of the sea with an ordinary thermometer. Besides, the thermometer is subjected, in the lower regions, to the enormous pressure of the upper layers, that of one atmosphere for every ten metres; even if the instrument is not broken, it will be crushed; the diameter of the tube getting smaller, the mercury will indicate a higher temperature for the same expansion, and, therefore, the reading of the thermometer will be too high. It took almost two centuries to resolve these perplexing problems.

Without going into details about the different suggestions worked out to reach a solution of the problems, suffice it to say that the best of all the thermometers that have been invented so far for taking the temperature of the lower regions is the Negretti-Zambra reversing thermometer; this is the one we used in our determinations. Negretti and Zambra invented this thermometer in 1878 and it has undergone no essential changes since that time. It is noteworthy to remark here that in this type there is a narrowing of the tube just above the bulb and, when the thermometer is placed with the bulb pointing downwards, the mercury fills the tube above the narrowing to a greater or less extent according to the temperature. If the thermometer is tipped over, either by the closing of the water-bottle, as it happens with the Petterson-Nansen bottle, or while a messenger is sent down the wire, as in the case of the Ekman reversing apparatus, the mercury breaks off at the narrowing and the mercury which was above this point sinks down to the opposite end of the tube and fills it to a certain height; a scale on the tube thus gives the temperature at the time the thermometer was turned over: that is called the temperature *in situ*. The length of the broken thread of mercury varies somewhat in passing through water of higher or lower temperature and this change is calculated when the temperature of the mercury is known at the time of the reading, and this is the reason why there is always with the apparatus a second ordinary thermometer that gives the reading temperature so that the correction may be made. In order that the thermometer may be able to withstand the pressure of the water, it is placed inside a strong glass tube.

SALINITY.

Since there is no element that is absolutely insoluble, every element is found to a certain degree in sea-water. By very accurate analysis, elements which one would not expect to find have been discovered in it; common metals, such as iron, manganese and zinc, as well as precious metals, like gold and silver are found in sea-water. Those rarer metals, being present only in infinitesimal quantities, are not detected by the ordinary methods of analysis.

The water of the ocean evaporates, condenses and falls again upon the earth in the form of rain; it washes the earth, oozes through it and by the streams and rivers is carried back to where it started from. This water, coming in contact with all sorts of


Salinity Sections
Mêtres
0
5
10
15
20
25
S.28.50
S.29.00
S.29.50
S.30.00
S.30.50
S.31.00
S.31.50
S.32.00
July 26th.
Aug. 10th.
July 17th.
July 18th (9.15am)
Aug. 14th. (6.00 a.m.)
July 18th. (11.30 a.m.)
July 18th. (2.00 p.m.)
Aug. 14th. (12.00 p.m)

substances, takes up all that it can dissolve and carries it down into the ocean and, though the quantity of a substance which goes into solution may be comparatively small, we understand how it is that the sea contains such diverse elements.

The two predominant elements which are found in the water of the sea are chlorine and sodium. It seems logical to admit that the sea was always salt since we find in the ocean of to-day certain shells which require a definite salinity and which were quite abundant in the Cambrian seas.

Dittmar gives the following composition and percentage of the salts in sea-water:—

Sodium chloride, Na Cl	27·213	gr. per litre.
Magnesium chloride, Mg Cl_2	3·807	" " "
Magnesium sulphate, Mg SO_4	1·658	" " "
Calcium sulphate, Ca SO_4	1·260	" " "
Potassium sulphate, K_2 SO_4	0·863	" " "
Calcium carbonate, Ca CO_3	0·123	" " "
Magnesium bromide, Mg Br_2	0·076	" " "
	35·000	" " "

Thoulet gives a somewhat different composition, though the amount of total salts is much the same, 35·0631 gr. per thousand grams of sea-water:—

Sodium chloride, NaCl	27·3726	gr. per kilog.
Potassium chloride, K Cl	0·5921	" " "
Rubidium chloride, Rb Cl	0·0190	" " "
Calcium sulphate, Ca SO^4	1·3229	" " "
Magnesium sulphate, Mg SO^4	2·2434	" " "
Magnesium chloride, Mg Cl_2	3·3625	" " "
Magnesium bromide, Mg Br_2	0·0547	" " "
Calcium metaphosphate, Ca $(PO_3)_2$	0·0156	" " "
Calcium bicarbonate, Ca C^2 O^3	0·0625	" " "
Iron bicarbonate, Fe C_2 O_3	0·0149	" " "

From the analyses that have been made of a great many samples of sea-water, it can be stated that there are about 35 grams of salt in a thousand grams of sea-water. This amount is greater in some regions, for instance in the tropical regions and in the gulf stream, where evaporation is more intense. It is much less in other parts, especially near the continental shores where the flow of fresh water from the coast lessens the proportion of salt. For instance, in my determinations, I found as low as 15·13 gr. per thousand at *Prince* Station 18, 19·18 per thousand at Station 20, 18·35 per thousand at Station 21, 15·63 per thousand at Station 22, etc. This is easily explained by the fact that there is at those points a mixture of fresh water from the coast.

However, the average amount of salt in the ocean is about 35 gr. per thousand parts by weight. In the percentage of salts given by Dittmar and Thoulet, the acids and bases have been arbitrarily combined. Still it is very probable that in the water the salts are not found as indicated. The elements and acid radicals are found by analysis, but nothing tells us how they exist in solution. The dissolved substances mainly exist as ions, and from the freezing point and boiling point of sea-water, we calculate the ionic dissociation to be about 90 per cent; thus, only one-tenth of the total solids are present in the water as salts. It would be better, therefore, to write the composition of the solids in sea-water, as it is given by Dr. Johan Hjort:—

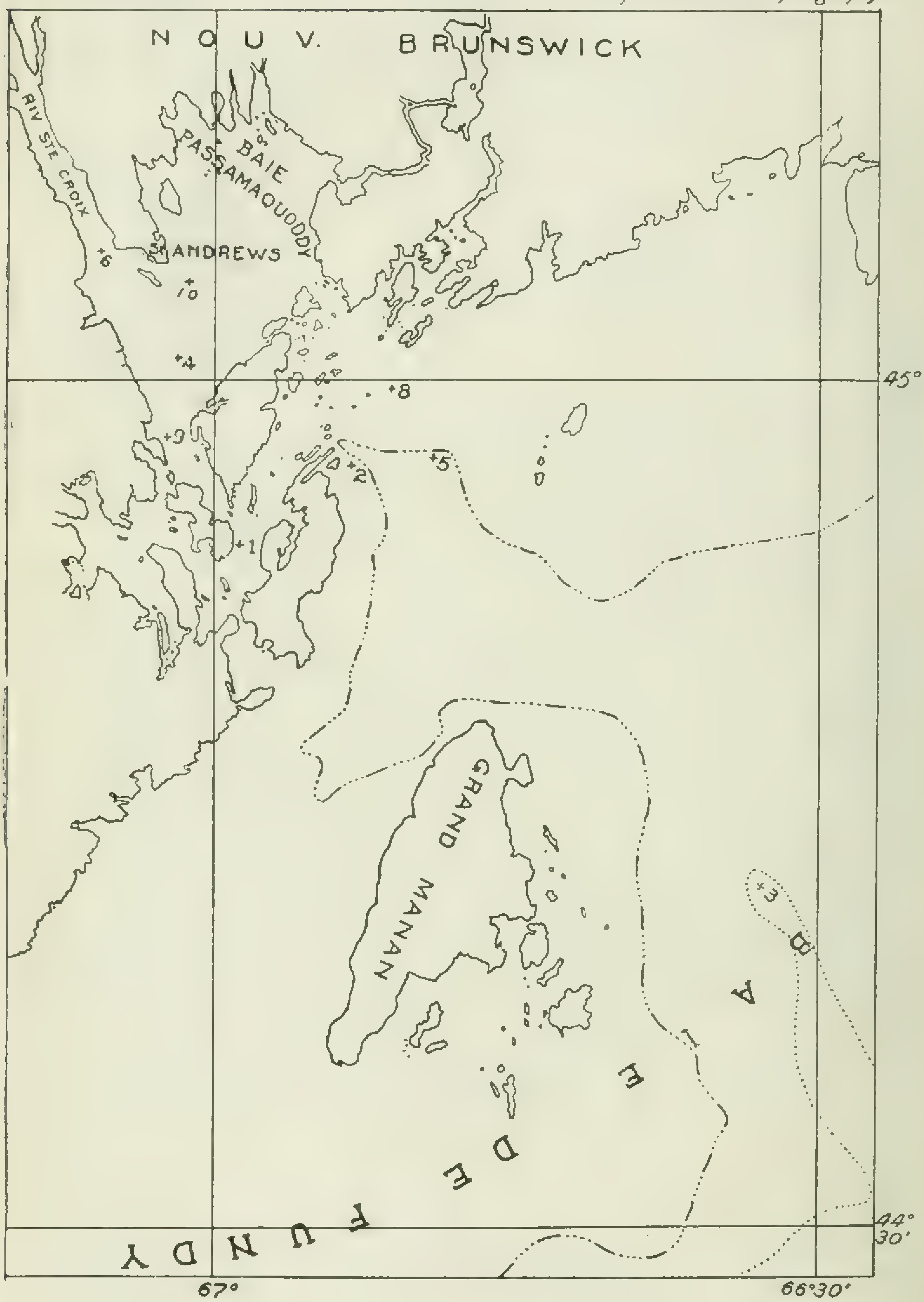
Na	10·722	parts per 1000	30·64%
Mg	1·316	" " "	3·76%
Ca	0·420	" " "	1·20%
K	0·382	" " "	1·09%
Cl	19·324	" " "	55·21%
SO_4	2·696	" " "	7·70%
CO_3	0·074	" " "	0·21%
Br	0·066	" " "	0·19%
	35·000		100·00%

From the foregoing, one can readily perceive that the salinity of sea-water is not identical everywhere in the ocean; it varies in different regions and at different depths.

WESTERN ARCHIPELAGO

Prince Stations

Professor Vachon, Hydrography.



A necessary condition to make a determination of the salinity of sea-water is to secure a sample of water collected at a certain date in a certain place, at the surface or at a known depth, which is guaranteed free from mixture with different water and which has in no way evaporated.

The surface water can be collected in a bucket and hauled up. The glass bottle in which the water is to be preserved for analysis is rinsed with a portion of the sample, then filled, well stoppered and it can be kept as long as the bottle is almost completely filled and hermetically closed.

From July 14 to July 25 my samples were kept in Imperial pint bottles; after the latter date I used citrate of magnesia bottles. I took the temperature of the surface from the water in the bucket by means of a Centigrade thermometer graduated in tenths of a degree and whose accuracy I had verified beforehand.

To collect samples from below the surface, a great number of methods have been invented. At first, an ordinary stoppered bottle was sent down to a certain depth by means of a weight, and, at the desired depth, the bottle was opened and filled with water by pulling a cord attached to the stopper. In drawing it up, very little water from the surface layers could mix with the sample.

The Petterson-Nansen bottle, which we used for collecting our samples from July 14 to July 25, can isolate a sample of water at any depth. This bottle is sent down open, the lid being suspended in the upper part of the frame and held by a spring. We used the reversing thermometer attached to the frame of the bottle. We left the bottle at the desired depth for five minutes so that the thermometer could have time to accurately mark the temperature of the water *in situ*. A messenger was then sent down along the wire; this messenger unhooks the lid; the weight, which hangs below the apparatus, clasps the whole thing together and closes the bottle. This is composed of a series of metallic cylinders to insulate the water and a thermometer can be placed on the inside; this thermometer, which, however, is but slightly affected by varying temperatures as the bottle is pulled up, was not used in our determinations.

When we used the Petterson-Nansen bottle, the depth was taken in fathoms, as the meter-wheel had not arrived at the station, but, in my tables, the fathoms are expressed in metres.

From July 25, we used the Nansen reversing bottles for collecting our samples and the meter-wheel or determining the depth. The Nansen bottle has attached to it a thermometer which is tipped over with the bottle by means of a messenger. We allowed this bottle to remain at least three minutes in the water before pulling it up for a reading. A number of these bottles can be fastened along the line; a messenger is hooked below each bottle, except the lowest one; this messenger is released when the bottle is tipped over by means of a messenger sent from above; the result is that the next bottle is reversed; this releases another messenger and so on. By this apparatus, a number of samples can be taken at the same time at different depths and the bottles are not so heavy and clumsy as the Petterson-Nansen bottle.

The samples of water collected must afterwards be analysed. In such analysis the halogens are titrated with silver nitrate and the results given as grams of chlorine per thousand grams of water.

We have seen that there are many substances in sea-water, and, though the proportion of salts varies from one place to another, the relative proportion of the different elements is about the same everywhere; thus, when the quantity of chlorine has been accurately determined, we have the proportion of total salts in the sample examined. Mohr's method is used for the determination of chlorine. If a neutral or slightly alkaline solution of a chloride, bromide or iodide, in which there is a little potassium chromate comes in contact with a neutral solution of silver nitrate a white precipitate is formed as long as there is a trace of halide in solution. Thus, in sea-water, the bromine and small amount of iodine present are precipitated along with the chlorine, but the whole is calculated in grams of chlorine per thousand grams of water. As soon

as the last trace of halide is precipitated, the potassium chromate indicates the end of the reaction by forming a red precipitate with the silver nitrate. If the strength of the silver nitrate has already been determined with a solution of chloride of known strength, the amount of halides in the unknown solution or in the sea-water that is analysed can be found by simple proportion. The solution of known strength which is used in hydrography for standardizing the silver nitrate solution is the sample of "normal water" which is furnished in closed glass tubes by the International Council. The amount of chlorine is marked on the tube; the sample I used contained 19·386 parts of chlorine per thousand grams. When possible, it is well to have a few bottles of the "normal water" in order to occasionally titrate the silver nitrate solution; the amount of chlorine indicated on the tube is not absolutely reliable after the tube is two-thirds empty.

As Doctor Huntsman could only obtain, last summer, and with considerable trouble, one tube of "normal water," we had to be satisfied with that.

Here I desire to express my gratitude to the Biological Board, and especially Professor Macallum, for the opportunity of taking up this study, to Dr. Huntsman, the zealous and active curator of the Biological Station at St. Andrew's, who gave so generously both of his time and of his experience to help me in every possible way in my work, and to Sir George Garneau, professor of analytical chemistry in Laval University, who helped me in the salinity determinations.

For accurate sea-water analysis, a special burette is desirable: the ordinary burette is too wide and too short for the required accuracy. The reading should be certain to a hundredth part of a c.c., which is difficult with the ordinary burette. Besides, the "drainage error" is greater than in the special one, the upper part of which is an ungraduated bulb that terminates in a fine jet. The lower part of this burette is a narrow tube graduated in hundredths of a c.c. At the present time it is most difficult, not to say impossible, to obtain one of those special burettes. Dr. Huntsman was able to get one from Dr. Mathews, of the Plymouth Marine Biological laboratory, England, but, most unfortunately, it was broken when it reached me. Two others, made to order by the Eimer and Amend Company also arrived in a broken state. We hope to be fully equipped with all the special apparatus in the near future.

DENSITY.

The density of sea-water can be taken with a pycnometer, or else with an areometer, at constant temperature; the second method is less accurate. But the densities, though they may be accurately determined by either of the methods, do not give the exact density of the water *in situ*, where it possessed a certain temperature and was compressed by a mass of water. The density of sea-water is inversely proportionate to the temperature and directly proportionate to the salinity; the lower the temperature and the higher the percentage of salts, the heavier the water. When both the temperature and the salinity of a sample of water are known, the specific gravity may easily be calculated by means of Knudsen's tables.

When I reached the Biological Station, I began my work by making salinity determinations of samples of water which had been collected a year before in St. Mary's Bay and the Annapolis Basin. The Imperial pint bottles that contained those samples were not hermetically closed; there was a deposit of salt on the covers and frequently on the outside of the bottles.

Supposing the water had evaporated, one would expect a high percentage of salts; nevertheless, the results are low, and though I give them in the tables, I can, in no way, guarantee their accuracy. There are other results obtained with samples taken at the same stations in September and October.

The other samples of water were collected on the given dates at stations chosen by Dr. Huntsman, where a study of the plankton is carried on along with the hydrography.

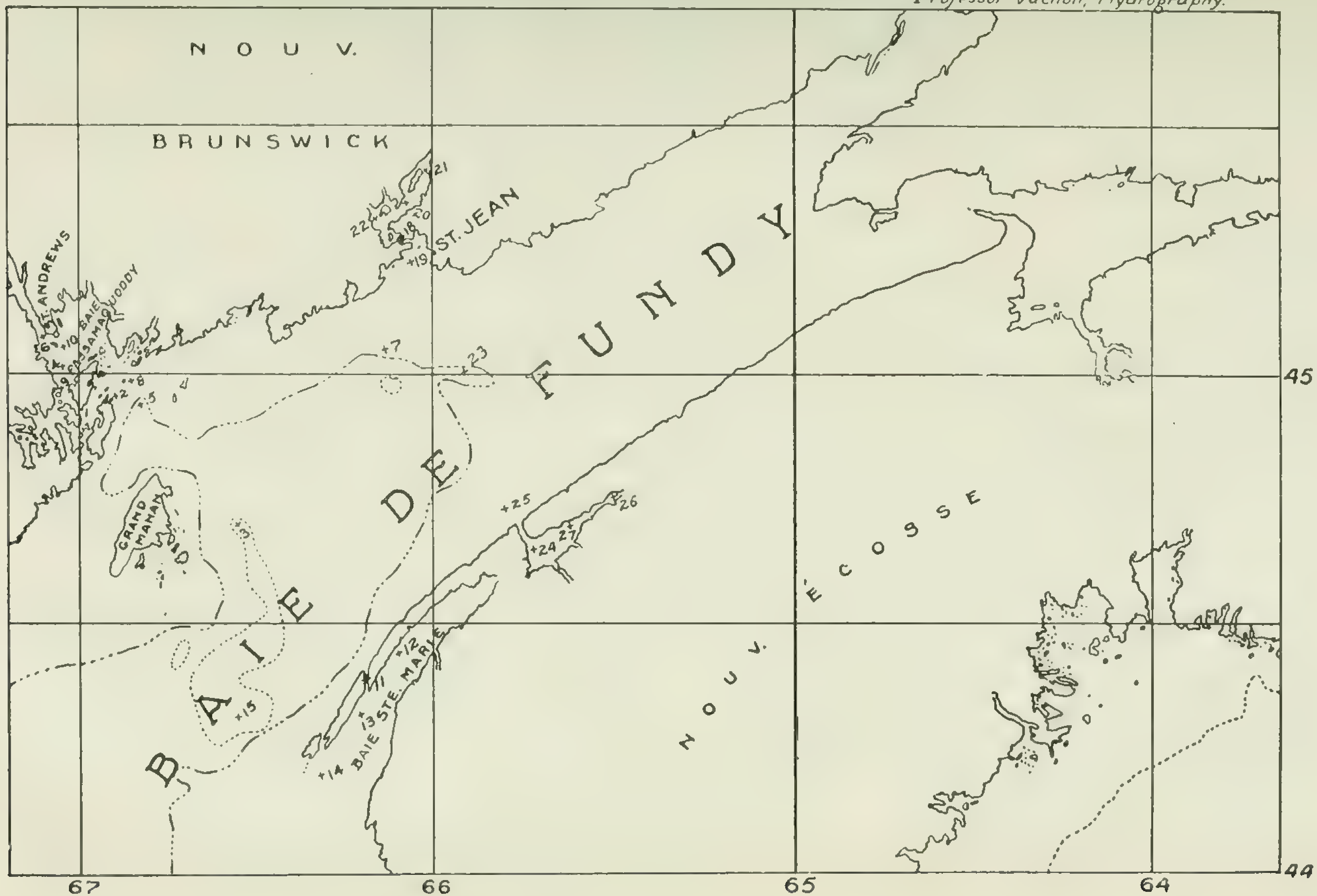
At *Prince* Station 1, we find a higher temperature and lower salinity at 30 metres than at 20 which showing the water at this point was in a state of unstable equilibrium, a layer of higher density being above one of lower density. As a general rule, such strange results were obtained with many of the water-samples collected later in the season. For instance, at *Prince* Station 4, the results are normal until September 15. Then we find a salinity of 31·13 ‰ at 35 metres when the salinity at 30 metres was as high as 32·57 ‰, giving a density of 23·96 for the first and 25·10 for the second. At the same station, on October 3, we obtained a salinity of 30·73 ‰ at 20 metres when that of the surface was 31·66 ‰. The same consideration can be made concerning Station 6, when we find on September 15 a temperature of 10·17 and a salinity of 31·67 ‰ at 35 metres whereas at 30 metres the temperature was 10·12° and the salinity 31·69 ‰. As one can see by the tables, a number of water samples, collected at Station 6 in October, were lost, so we cannot say whether the extraordinary result mentioned is accidental. It will be seen also that at *Prince* station 6 the salinity varies greatly with the tide, especially at the surface and it is easy to understand that it should be so on account of the flow of fresh water from the Ste. Croix river, as station 6 is located in the mouth of the river, between the Biological Station and Robbinston. At station 9 on September 15 we find a zigzag of temperatures and salinities: the temperature rises somewhat from 10 to 20 metres while the salinity lowers; at 50 metres the salinity is 31·21 ‰ when we find 32·15 ‰ at 40 metres. the salinity afterwards rises normally to the bottom but the temperature rises also; however, from 50 metres down, the density increases in a normal manner. On October 3, we find at the same station (20 metres) a density of 23·88 between 24·34 at 10 and 24·40 at 30 metres. At station 16 we get a salinity of 32·63 ‰ at the surface, 32·07 ‰ at 10 metres and 31·47 ‰ at 20 metres. At 30 metres the salinity rises somewhat, but so does the temperature; there is another decrease in salinity at 40 metres. The high percentage of salts in the surface water of station 17 can be explained by the fact that the sample was collected in Yarmouth Harbour, where the depth is only 13 metres, and, therefore, the water is easily mixed.

All the bottles, except one, were broken, which contained the samples collected at Station 20; it is unfortunate as the temperatures predicted interesting figures for the salinity. From a depth of 10 metres down the temperature rises, 6·08° at 10 metres, 6·43 at 15 m., then 8·22, 10·98, 11·74, 11·93, 12·00. Perhaps the upper layers had been first cooled down to a certain depth, and that they had begun to get warmer again as the air temperature rose. But a fact worthy of attention in this particular case is that the temperature of the surface water is 15·69° when the air temperature is 11·80°. At station 21 there is also a decrease of temperature from the surface to a depth of 20 metres, but there is a rise of temperature from 30 metres to the bottom. However, at this station, as the salinity rises from the upper layers to the bottom, the increase of density is also normal. The temperatures taken at station 24 deserve special attention from the fact that there is very little difference between the surface temperature and that of the bottom, 9·37° at the surface and 9·29° at 55 metres. From 9·37° at the surface we get 9·32°, 9·31°, 9·28°; then a rise 9·29°, 9·30°; a slight fall to 9·28° and 9·29° at the bottom. These temperatures were taken at 9·20 a.m. The same day, at 5.45 in the afternoon, we have somewhat equivalent results, but the low salinity, instead of being at 50 metres, as in the forenoon when the tide was high is at 40 metres, at low tide. Two of the samples collected at station 24, September 23, 5.45 p.m. were lost; the others gave very extraordinary salinity results. The highest salinity, 32·37 ‰ is at the surface. We found 32·29 ‰ at 10 metres, 31·28 ‰ at 40 metres and 31·13 ‰ at 50 metres. A glance at the results given for stations 25 and 27 shows that at those stations also the density of the water was higher at the surface than at a certain depth. At station 25 we find a salinity of 32·47 ‰ at 10 metres and only 31·54 ‰ ten metres lower and so forth and so on.

BAY OF FUNDY

Prince Stations

Professor Vachon, Hydrography.



The following samples were collected by Mr. W. H. Chase, of Acadia University, a year before I reached the station. (The stations are indicated on a chart at the laboratory, at St. Andrews):—

Date.	Station.	Depth.	Salinity S. ‰.
July 7, 1915.	St. Mary's bay, No. 1	Bottom	29·18
" 7, 1915.	" " 2	"	31·20
" 7, 1915.	" " 3	"	31·89
" 7, 1915.	" " 4	"	30·76
" 7, 1915.	" " 5	"	30·70
" 7, 1915.	" " 6	"	31·47
" 7, 1915.	" " 7	"	31·48
" 8, 1915.	" " 8	"	30·78
" 8, 1915.	" " 9	"	30·18
" 7, 1915.	" " 10	"	30·76
" 13, 1915.	" " 11	"	30·06
" 8, 1915.	" " 12	"	31·45
" 13, 1915.	" " 13	"	30·80
" 8, 1915.	" " 14	"	29·86
" 8, 1915.	" " 15	"	30·91
" 8, 1915.	" " 16	"	30·77
" 13, 1915.	" " 17	"	30·18
" 13, 1915.	" " 18	"	29·99
" 13, 1915.	" " 19	"	29·86
" 13, 1915.	" " 20	"	30·25
" 13, 1915.	" " 21	"	30·38
" 13, 1915.	" " 22	"	30·78
" 23, 1915.	Annapolis basin, No. 25	Surface	29·99
" 23, 1915.	" " 25	27·3 metres	30·40
" 24, 1915.	" " 28	Surface	30·52
" 24, 1915.	" " 28	Bottom	30·53
" 23, 1915.	" " 29	Surface	30·63
" 23, 1915.	" " 29	Bottom (6·3 m.)	30·74
" 23, 1915.	" " 30	" (4·6 m.)	29·79
" 24, 1915.	" " 31	Surface	30·05
" 24, 1915.	" " 31	Bottom	30·77
June 22, 1915.	Black Rock	72·7 metres	26·69
July 14, 1916.	Off Wilson's beach	Surface	30·88 t°=8·8

SAMPLES

"Prince" Stations. No.	Locality.	Position (vide chart).	Latitude.	Longitude.	Bottom.
1........	Friar Roads, just south Coffin Ledge buoy.	Bald Head bears E½ N. Deer Id. Point bears N. x W½ W.	44° 54′ 27″ N.	66° 58′ 11″ W.	Hard. Rocky.
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	.
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
1........	" "	" c	"	"	"
1........	" "	" "	"	"	"
1........	" "	" "	"	"	"
2........	Bay of Fundy, off Head Harbour Id.	North end of Head Harbour Id. bears N.W. ½ W. ⅝ mile. Scott Head bears S.W. x S. ½ S., 2½ miles.	44° 56′ 58″ N.	66° 53′ 0″ W.	Soft mud.

COLLECTED.

Date.	Hour.	Depth in Metres.	Air Temperature t° C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Water Temperature t° C.	Chlorine. Cl. ‰.	Salinity. S. ‰.	Density. σt.	Colour of Water.
1916.												
July 25	11.50 a.m..	32·7	9·44	2½ hours of low tide.	S. W. breeze..	Cloudy.	Surface.	9·00	17·43	31·48	24·39	
" 25	12.10 p.m..	32·7	9·44	"	"	"	20 m.	7·90	17·49	31·61	24·66	
" 25	11.50 a.m..	32 7	9·44	"	"	"	28 "	7·40	17·50	31·62	24·72	
Aug. 2	4.00 p.m..	32·7	9·02	2¼ hours ebb.	Calm..	"	Surface.	8·70	17·31	31·27	24 28	
" 2	4.00 "	32·7	9·02	"	" ...	"	10 m.	8·30	17·32	31·29	24·26	
" 2	4.00 "	32·7	9·02	"	" ...	"	20 "	8·28	17·36	31·36	24·42	
" 2	4.00 "	32·7	9 02	"	" ..	"	30 "	8·10	17·36	31·36	24·44	
" 19	1.20 "	43 m.	12·00	½ hour to high tide.	" ...	Clear...	Surface.	8·7	17·56	31·73	24·65	
" 19	1.20 "	43 "	12·00	"	" ..	" .	10 m.	8·25	17·63	31·86	24·81	
" 19	1.20 "	43 "	12·00	"	" ..	" ..	20 "	9·31	17·62	31·83	24 76	
" 19	1.20 "	43 "	12·00	"	" ...	" .	30 "	8·29	17·60	31·81	24·75	
" 19	1.20 "	43 "	12·00	"	" ...	" ..	40 "	8·23	17·59	31·79	24·75	
" 31	3.35 "	35 "	15·60	2¼ hours to low tide.	S. W. breeze.	" ..	Surface.	9·52	17·63	31·84	24·61	
" 31	3.35 "	35 "	15·60	"	"	" .	20 m.	9·10	17·67	31·93	24·72	
" 31	3.35 "	35 "	15 60	"	"	" ..	30 m.	9·08	17·67	31·93	24·72	
Sept. 14	3.20 "	32 "	22·63	2 hours ebb.	Calm...	" ..	Surface.	10·30	17·30	31·25	24·01	Bluish
" 14	3.20 "	32 "	22·63	"	" ...	" .	10 m.	9·54	Sam-	ple	lost.	
" 14	3.20 "	32 "	22·63	"	" ...	" .	20 "	9·43	17·81	32·18	24·86	"
" 14	3.20 "	32 "	22·63	"	" ...	" ..	25 "	9·45	17·70	31 99	34·71	"
Oct. 3	3.45 "	35 "	13·81	High...	Light S. W.	" ..	Surface.	9·30	Sam-	ple	lost.	Greenish.
" 3	3.45 "	35 "	13·81	"	"	" ..	10 m	9·21	"	"	"	"
" 3	3.45 "	35 "	13·81	"	"	" ..	20 "	9·13	17·81	32 18	24·94	"
" 3	3.45 "	35 "	13·81	" ..	"	" ..	30 "	9·15	17 69	31·96	24·74	"
" 17	10.11 a.m..	44 "	12·45	Low	S. W. strong.	Clouds, rain.	Surface.	9·02	No	water.		
" 17	10.11 "	44 "	12·45	"	"	"	20 m.	8·81	"	"	...	"
" 17	10.11 "	44 "	12·45	" ...	"	"	40 "	8·78	"	"	..	"
....	....	100 "	No determinations were made at Station No. 2.									

SAMPLES

"Prince" Stations No.	Locality.	Position (vide chart.)	Latitude.	Longitude.	Bottom.
3	Bay of Fundy, off Grand Manan Island.	Swallow-tail light bears N. W. ¼ W., 9 miles. Southern point of Whitehead Id. bears W. x S. ¾ S. 8¼ miles.	44° 42′ 5″ N...	66° 32′ 31″ W.	Soft mud..
3.......	" "	" "	"	"	"
3.	" "	" "	"	"	"
3.	" "	" "	"	"	"
3.........	" "	" "	"	"	"
3. ..	" "	" "	"	"	"
3.	" "	" "	"	"	"
3.	" "	" "	"	"	"
3.	" "	" "	"	"	"
3.	" "	" "	"	"	"
3.... ...	" "	" "	"	"	"
3	" "	" "	"	"	"
3.........	" "	" "	"	"	"
3.	" "	" "	"	"	"
3..... ...	" "	" "	"	"	"
3	" "	" "	"	"	"
3	" "	" "	"	"	"
3	" "	" "	"	"	"
3.	" "	" "	"	"	"
3.........	" "	" "	"	"	"
3.	" "	" "	"	"	"
3.	" "	" "	"	"	"
3...	" "	" "	"	"	"
3...	" "	" "	"	"	"
3...	" "	" "	"	"	"
4	Passamaquoddy Bay.	Joe's point bears N. by W. ¼ W. 4½ miles. Northern p int of Pendleton Id. bears E. 3¼ miles.	45 1′ 0″ N.	67° 1′ 51″ W.	Soft mud.
4	" "	" "	"	"	"
4.	" "	" "	"	"	"
4	" "	" "	"	"	"
4.	" "	" "	"	"	"
4 . ..	" "	" "	"	"	"
4	" "	" "	"	"	"
4.	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	
4...... .	" "	" "	"	"	"
4	" "	" "	"	"	"
4.... .	" "	" "	"	"	"
4...	" "	" "	"	"	"
4..... ...	" "	" "	"	"	"
4.	" "	" "	"	"	"
4.	" "	" "	"	"	"
. . ....	" "	" "	"	"	"
... ...	" "	" "	"	"	"
....	" "	" "	"	"	"

COLLECTED—*Con.*

Date.	Hour.	Depth in metres.	Air temperature t° C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Water temperature t° C.	Chlorine Cl. ‰.	Salinity S. ‰.	Density σt.	Color of Water.
1916.												
July 24	12.20 p.m.,	188 m.	14·42	½ hour to low water.	S. E..	Cloudy rain.	Surface.	10·00	16·84	30·43	23·41	
" 24	12.50 "	188 m.	14·42	"	"	"	45 m.	5·90	17·87	32·29	25·46	
" 24	12.35 "	188 m.	14·42	"	"	"	90 "	4 50	18·05	32·60	25·85	
" 24	12.20 "	188 m.	14·42	"	"	"	150 "	4·90	18 06	32·62	25·84	
" 24	12.00 noon.	188 m.	14·42	"	"	"	185 "	4·90	18 06	32·62	25·84	
Aug. 25	11.54 a m..	185 m	13·28	2¼ hours ebb.	S.W. breeze.	Fog . .	Surface.	10·98	17·58	31 77	24·29	
" 25	12.54 p.m..	185 "	13·28	"	"	"	10 m.	9·87	17·66	31·91	24·60	
" 25	12.54 " ..	185 "	13·28	"	"	"	25 "	9·11	17·66	31·91	24·71	
" 25	12.54 " ..	185 "	13·28	"	"	"	50 "	7·43	17·94	32·41	25·35	
" 25	12.34 " ..	185 "	13·28	"	"	" ...	75 "	6·47	18·05	32·60	25·61	
" 25	12.34 " ..	185 "	13·28	"	"	" ...	100 "	6·10	18·19	32·85	25·88	
" 25	12.34 " ..	185 "	13·28	"	"	"	125 "	6·02	18·22	32·93	25·94	
" 25	12.15 " ..	185 "	13·28	"	"	"	150 "	5·83	18·22	32·93	25·98	
" 25	12.15 " ..	185 "	13·28	"	"	" ...	175 "	5·82	18·24	32 95	25·98	
Oct. 4	2-00 " ..	173 m.	15·48	1 hour flood.	Light S. W.	Hazy...	Surface.	11·07	Sampl	e lost.	. .	Dark Green
" 4	2.23 " ..	173 "	15·48	"	"	" ...	10 m.	10·05	17·67	31·92	24·58	"
" 4	2.13 " ..	173 "	15·48	"	"	" ...	20 "	9·67	Sampl	e lost.	....	"
" 4	2.13 " ..	173 "	15·48	"	"	" ...	25 "	8·71	17·93	32·39	25·16	"
" 4	2.13 " .	173 "	15·48	"	"	" ...	30 "	8·59	17·97	32·47	25·24	"
" 4	2.00 " ..	173 "	15·48	"	"	" ..	40 "	8·27	Sampl	e lost.	....	"
" 4	2.00 "	173 "	15·48	"	"	" ...	50 "	7·92	18·05	32·61	25·44	"
" 4	2.00 " ..	173 "	15·48	"	"	" ...	75 "	6·70	17·94	32·42	25·46	"
" 4	1.45 " .	173 "	15·48	"	"	" ...	100 "	6·35	Sampl	e lost	....	"
" 4	1.45 " ..	173 "	15·48	"	"	" ...	150 "	6.12	17·99	32·51	25·59	"
" 4	1.45 " ..	173 "	15·48	"	"	" ..	173 "	6·15	18·25	32 98	25·95	"
July 20	3.30 " ..	30 "	23·00	1 hour to high tide.	"	Bright..	Surface.	11·40	16·80	30·36	23·11	
" 20	3.30 " ..	30 "	23·00	"	"	" ..	9 m.	8·80	17·15	30·99	24·07	
" 20	3.30 " ..	30 "	23·00	"	"	" ...	18·3 "	8·30	17·23	31·13	24·22	
" 20	3.30 "	30 "	23·00	"	"	" ...	27·4 "	8·10	17·28	31·23	24·32	
" 27	3.30 " ..	30 "	25·00	1 hour to low tide.	S.W. breeze.	Bright..	Surface.	15·90	16·03	28·97	21·18	
" 27	3.30 " ..	30 "	25·00	"	"	"	10 m.	9·80	16 91	30·56	23·57	
" 27	3.30 " ..	30 "	25·00	"	"	"	15 "	8·79	17·21	31·09	24·14	
" 27	3.30 " ..	30 "	25·00	"	"	"	25 "	8·50	17·28	31·22	24·29	
Aug. 3	4.00 " .	30 "	16·30	1 hour ebb..	"	Cloudy.	Sur. face.	11·0	16·75	30·27	23 12	
" 3	4.00 "	30 "	16·30	"	"	"	10 m.	8·92	17 15	30·99	24·02	
" 3	4.00 " ..	30 "	16·30	"	"	"	20 "	8·91	17·15	30 99	24·02	
" 3	4.00 " ..	30 "	16·30	"	"	"	30 "	8·85	17·20	31·07	24·21	
Aug. 10	5.30 p.m.	29 m.	21·70	Half flood.	Calm.	Clear.	Surface.	13·22	16·71	30·19	22·67	
" 10	"	"	"	"	"	"	10 m.	9·30	17·12	30·94	23·91	
" 10	"	"	"	"	"	"	20 m.	9·19	17·20	31·08	24·04	
" 10	"	"	"	"	"	"	25 m.	9·01	17·21	31·09	24·09	
" 17	5.00 p.m.	33 m.	17·80	Half ebb.	Light S.E.	Hazy.	Surface.	10·95	16 92	30·58	25·36	
" 17	"	"	"	"	"	"	10 m.	9·80	17·12	30 94	23·84	
" 17	"	"	"	"	"	"	20 m.	9·43	17·33	31 32	24.19	
" 17	"	"	"	"	"	"	30 m.	9·10	17·46	31·55	24·40	

SAMPLES

"Prince" Stations. No.	Locality.	Position (vide chart).	Latitude.	Longitude.	Bottom.
	Passamaquoddy Bay.	Joe's Point bears N. by W. ¼ W. 4½ miles, Northern point of Pendleton Id. bears E. 3⅓ miles.	45° 1′ 0″ N.	67° 1′ 51″ W.	Soft mud.
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
4	" "	" "	"	"	"
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	Bay of Fundy, between Head Harbour and the Southern Wolves.	Head Harbour Lt. bears N.W. by W. ½ W., 3⅞ miles- Swallow Tail Lt. bears a little W. of S. 11⅓ miles.	44° 56′ 48″ N.	66° 48′ 41″ W.	
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COLLECTED—*Con.*

Date.	Hour.	Depth in Metres.	Air Temperature t° C.	Tide.	Wind.	Sky.	Depth of Determinations in metres.	Water Temperature t° C.	Chlorine. Cl. °/₀₀	Salinity. S. °/₀₀	Density. σt.	Colour of Water.
1916.												
Aug. 16	1.35 p.m.	120 m.	12·00	¾ hour to high tide.	S.W. breeze choppy.	Hazy.	Surface.	9.60	17.40	31.45	24.27	
" 25	4.45 p.m.	28 m.	14·31	1½ hour flood	Calm.	Foggy.	Surface.	12·48	no sa	mple	of wa	ter.
" 25	"	"	"	"	"	"	15 m.	9·50	"	"	"	
" 25	"	"	"	"	"	"	25 m.	9·57	"	"	"	
" 31	12.50 p.m.	31 m.	14·91	½ hour to high tide.	"	Clear.	Surface.	14·91	17·03	30·77	22·73	
" 31	"	"	"	"	"	"	20 m.	10·07	17·48	31·59	24·30	
" 31	"	"	"	"	"	"	30 m.	10·01	17·49	31·61	24·33	
Sept. 15	5.00 p.m.	36 m.	13·88	½ ebb.	S.E., light breeze.	Hazy.	Surface.	10·95	17·25	31·17	23·82	Grayish.
" 15	5.15 p.m.	"	"	"	"	"	10 m.	10·26	17·42	31·48	24·19	"
" 15	5.00 p.m.	"	"	"	"	"	20 m.	10·07	18·02	32·56	25·07	"
" 15	"	"	"	"	"	"	30 m.	9·98	18·03	32·57	25·10	"
" 15	"	"	"	"	"	"	35 m.	9·98	17·23	31·13	23·96	"
Oct. 3	10.20 a.m.	31 m.	13·20	Low.	Calm.	Clear.	Surface.	10·60	17 52	31·66	24·28	"
" 3	"	"	"	"	"	"	10 m.	9·96	sam	ple lo	st.	
" 3	"	"	"	"	"	"	20 m.	9 83	17·01	30·73	23·71	"
" 3	"	"	"	"	"	"	30 m.	9·82	17·60	31·81	24·56	"
" 3	"	"	"	"	"	"	.					
" 16	12.53 p.m.	30 m.	12·41	2½ hours to high water.	Moderate S.W.	Cloudy.	Surface.	9·35	sam	ple lo	st.	"
" 16	"	"	"	"	"	"	20 m.	9·14	"	"		"
" 16	"	"	"	"	"	"	30 m.	8·98	"	"		"
" 21	2.07 p.m.	27 m.	13·38	½ hour flood.	Strong S.W.	Cloudy, rain.	Surface.	9·32	no	water	samp	le.
" 21	"	"	"	"	"	"	10 m.	9·18	"	"	"	"
" 21	"	"	"	"	"	"	20 m.	9·08	"	"	"	"
" 21	"	"	"	"	"	"	26 m.	8·88	"	"	"	"
" 27	9.16 a.m.	30 m.	6 21	½ hour flood.	Moder. N.W.	Clear.	Surface.	8·51	"	"	"	Gre'nish.
" 27	"	"	"	"	"	"	20 m.	8·81	"	"	"	"
" 27	"	"	"	"	"	"	30 m.	8·80	"	"	"	"
July 25	9.00 a.m.	90 m.	12·80	High.	S.W. breeze.	Clear.	Surface.	8·50	17·42	31·47	24·28	
" 25	"	"	"	"	"	"	28 m.	7·40	17·48	31·59	24·70	
" 25	"	"	"	"	"	"	45 ...	6·90	17·61	31·82	24·97	
" 25	"	"	"	"	"	"	65 m.	6·40	17·61	31·82	25·03	
" 25	"	"	"	"	"	"	85 m.	5·90	17·69	31·96	25·21	
" 16	1.25 p.m.	"	"	"	"	"	10 m.	9.02	17.49	31.60	24.49	
" 16	1.30 p.m.	"	"	"	"	"	25 m.	8.33	17.54	31·70	24.66	
" 16	1.35 p.m.	"	"	"	"	"	50 m.	8.31	17.62	31.84	24.80	
" 16	"	"	"	"	"	"	75 m.	7.92	17.62	31.84	24.85	
" 16	"	"	"	"	"	"	100 m.	6.64	17.87	32.29	25.37	
" 16	"	"	"	"	"	"	110 m.	6.40	17.92	32.38	25.45	
Sept. 18	11.09 a.m.	100 m.	13·12	Low tide.	Calm.	Clear.	Surface.	11.30	16.70	30.18	22.99	Gray.
" 18	11·24 a.m.	"	"	"	"	"	10 m.	10 08	16.92	30.58	23.53	"
" 18	"	"	"	"	"	"	20 m.	9.74	17.02	30.75	23.76	"

SAMPLES

"Prince" Stations. No.	Locality.	Position (vide chart).	Latitude.	Longitude.	Bottom.
5........	Bay of Fundy, between Head Harbour and the Southern Wolves.	Head Harbour Lt. bears N.W. by W. ½ W., 3⅞ miles. Swallow tail Lt. bears a little W. of S. 11½ miles.	44° 56′ 48″ N.	66° 48′ 41″ W.	Soft mud.
5........	" "	" "	"	"	"
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5........	" "	" "	"	"	"
6........	Ste. Croix River, between Biological Station and Robbinston.	Biological Station bears E. ¾ S., $\frac{5}{10}$ of a mile. Little Dochet Id. bears N. by W. ½ W., 2⅜ miles.	45° 4′ 49″ N.	67° 5′ 53″ W.	Fairly hard mud.
6........	" "	" "	"	"	"
6........	" "	" "	"	"	"
6........	" "	" "	"	"	"
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COLLECTED—*Con.*

Date.	Hour.	Depth in metres.	Air temperature t° C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Temperature t° C.	Chlorine. Cl.	Salinity. S.	Density. σt.	Colour of water.
1916.												
Sept. 18	11 13 a.m.	120 m.	12·00	¾ hour to high tide.	S.W. breeze choppy.	Hazy.	25 m.	9.55	17.17	31.02	23.95	Gray.
" 18	"	"	"	"	"	"	30 m.	9.51	17.71	32.00	24.72	
" 18	"	"	"	"	"	"	40 m.	9.32	17.72	32 02	24.75	"
" 18	11.00 a.m.	"	"	"	"	"	50 m.	9.08	17.84	32.23	24.98	"
" 18	"	"	"	"	"	"	75 m.	8.26	18 02	32.56	25 36	"
" 18	"	"	"	"	"	"	100 m.	7.61	18.04	32.60	25.47	"
Oct. 4	9.04 a.m.	99½ m.	10·4	Half ebb.	Light W.	Hazy.	Surface.	9.62	17.40	31.45	24.27	"
" 4	9.18 a.m.	"	"	"	"	"	10 m.	9.48	17.53	31.68	24.47	Gre'n-ish.
" 4	9.06 a.m.	"	"	"	"	"	20 m.	9.43	17.77	32.10	24.81	"
" 4	"	"	"	"	"	"	30 m.	9.36	17.78	32·13	24.84	"
" 4	"	"	10·40	"	"	"	40 m.	9.21	17.78	32·13	24.85	"
" 4	8.51 a.m.	"	"	"	"	"	50 m.	9.07	17.82	32.20	24.95	"
" 4	"	"	"	"	"	"	75 m.	8 85	17.82	32.20	24.97	"
" 4	"	"	"	"	"	"	99 m.	7.98	17.99	32.50	25.34	"
July 17	5.10 p.m.	31 m.	15·30	4 hours ebb.	S.W.	Cloudy.	Surface.	13.15	15.69	28.36	21.27	"
" 17	"	"	"	"	"	"	9.10 m	8.80	16.92	30.58	23.75	
" 17	4.50 p.m.	"	"	3 hrs. 40 m. ebb.	"	"	18.30 m.	8.30	17.12	30.94	24·07	
" 17	4.10 p.m.	"	"	3 hours ebb.	"	"	27.40 m.	8.30	17.22	31.10	24.21	
" 18	9.15 a.m.	"	14·00	1 hour flood.	Calm.	Foggy.	Surface.	12.10	15.68	28.33	21.45	
" 18	"	"	"	"	"	"	9.10 m	9.60	16.92	30.57	23 61	
" 18	9.00 a.m.	"	"	45 min. flood	"	"	18 30 m.	8 70	17.05	30.81	23.95	
" 18	8.45 a.m.	"	"	½ hour flood.	"	"	25 60 m.	8.60	17.08	30.87	24.00	
" 18	11 30 a.m.	"	15·10	3 hours flood	"	"	Surface.	11.50	16.60	29.99	22.82	
" 18	"	"	"	"	"	"	9.10 m	8.60	16.96	30 65	23.83	
" 18	11.15 a.m.	"	"	"	"	"	18.30 m.	8.10	17.22	31.11	24.24	
" 18	11.30 a.m	"	"	"	"	"	27.40 m.	8.10	17.23	31.14	24.25	
" 18	2.35 p.m.	"	16·30	High tide.	"	"	Surface.	12.80	16.70	30.17	22.73	
" 18	"	"	"	"	"	"	9.10 m	8.95	16.96	30.64	23.76	
" 18	2.00 p.m.	31 "	16·30	"	"	"	27·40 m.	8·10	17 20	31.08	24·22	
" 26	4.30 p.m.	31 "	21 00	Low tide circ.	"	Cloudy.	Surface.	13 40	15·34	27·72	20·71	
" 26	4.30 "	31 "	21·00	"	"	"	10 m.	9·84	16·55	29·90	23 04	
" 26	4.30 "	31 "	21·00	"	"	"	15 m	9·40	16·87	30 48	23·55	
" 26	4.30 "	31 "	21·00	"	"	"	25 m.	8·80	17·10	30·90	23·99	
Aug. 10	11.45 a.m.	30 "	18·50	½ flood	N. W. breeze.	Clear	Surface.	12·65	15·65	28 28	21·33	
" 10	11.45 "	30 "	18·50	"	"	"	10 m	9·60	16·93	30·59	23 62	
" 10	11.45 "	30 "	18·50	"	"	"	20 m.	9·30	17·14	30·98	23 96	
" 10	11.45 "	30 "	18·50	"	"	"	25 m.	9·37	17·17	31·02	23·98	
" 14	6.00 a.m.	28 "	11·90	Low tide	Strong N. W.	Cloudy.	Surface	10 95	16·01	28·94	22·10	

SAMPLES

"Prince" Stations. No.	Locality.	Position (vide chart).	Latitude.	Longitude.	Bottom
6...	Ste. Croix River between Biological Station and Robbinston.	Biological Station bears E. ¾ S., $\frac{6}{10}$ of a mile Little Dochet Id. bears N. by W. ½ W. 2⅘ miles.	45° 4′ 49″ N.	67° 5′ 53″ W	Fairly hard mud.
6.	" "	" "	"	"	"
5........	" "	" "	"	"	"
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SESSIONAL PAPER No. 38a

COLLECTED—*Con.*

Date.	Hour.	Depth in Metres.	Air Temperature t° C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Water Temperature t° C.	Chlorine. Cl. ‰.	Salinity. S‰.	Density. σt.	Colour of Water.
1916.												
Aug. 14	6.00 a.m.	28 m.	11·90	Low tide circ.	Strong..	Cloudy.	18·30 m.	10·95	16·01	28·94	22·10	
" 14	6.00 "	28 "	11·90	"	"	"	10 m.	.) 13	16·78	30·33	23·33	
" 14	6.00 "	28 "	11·90	"	"	"	20 m	9·91	16·98	30·69	23·65	
" 14	6.00 "	28 "	11·90	"	"	"	25 m.	9·68	17·12	30·93	23·86	
" 14	12.00 p.m.	33 "	12·20	High tide..	"	"	Surface.	10·40	16·96	30·64	23·51	
" 14	12.00 "	33 "	12·20	"	"	"	10 m.	9·70	17·03	30·77	23·75	
" 14	12.00 "	33 "	12·20	"	"	"	20 m.	9·55	17·18	31·03	23·97	
" 14	12.00 "	33 "	12·20	"	"	"	25 m	9·50	17·24	31·15	24·05	
" 14	12.00 "	33 "	12·20	"	"	"	30 m.	9·48	17·24	31·15	24·06	
" 18	8.30 a.m.	29 "	13·80	½ hour to low tide.	South breeze.	Hazy ..	Surface.	11·75 10·38	16·07 16·83	29·04 30·40	23·19 23·34	
" 18	8.30 "	29 "	13·80	"	"	"	10 m	10·09	17·13	30·95	23·82	
" 18	8.30 "	29 "	13·80	"	"	"	20 m.	10·06	17·15	30·98	23·83	
" 18	8.30 "	29 "	13·80	"	"	"	25 m.	14·22	15·62	28·22	20·96	
" 22	1.10 p.m.	28 "	22·38	Low tide...	Calm...	"	Surface.					
" 22	1.10 p.m.	28 "	22·38	"	"	"	10 m.	10·51	17·03	30·78	23·59	
" 22	1.10 p.m.	28 "	22·38	"	"		20 m.	9·83	17·24	31·16	24·01	
" 22	1.10 p.m.	28 "	22·38	"	"	"	25 m.	9·78	17·30	31·26	24·11	
" 23	8.20 a.m.	32 "	14·90	High tide...	S.E. breeze.	"	Surface.	12·29	16·93	30·59	23·10	
" 23	8.20 a.m.	32 "	14·90	"	"	"	10 m.	10·60	17·17	31·02	23·79	
" 23	8.20 a.m.	32 "	14·90	"	"	"	15 m.	10·29	17·21	31·10	23·88	
" 23	7.58 a.m.	32 "	14·90	"	"	"	20 m.	9·78	17·39	31·43	24·22	
" 23	7.58 a.m.	32 "	14·90	"	"	"	25 m.	9·69	17·43	31·49	24·30	
" 23	7.58 a.m.	32 "	14·90	"	"	"	30 m	9·68	17·43	31·49	24·31	
" 31	9.45 a.m.	28 "	15·20	2 hours flood	Calm...	Sunshine.	Surface.	12·52	16·14	29·17	22·00	
" 31	9.45 a.m.	28 "	15·20	"	"	"	20 m.	10·28	17·32	31·29	24·03	
" 31	9.45 a.m.	28 "	15·20	"	"	"	27 m.	10·26	17·34	31·34	24·07	
Sept. 15	12.03 p.m.	36 "	16·80	2 hrs to high tide.	Light S.E. breeze.	Clear ..	Surface.	11·73	16·70	30·17	22·92	Gray.
" 15	12.03 p.m.	36 "	16·80	"	"	"	10 m	10·31	17·26	31·19	23·88	"
" 15	12.03 p.m.	36 "	16·80	"	"	"	20 m.	10·21	17·54	31·69	24·32	"
" 15	12.03 "	36 "	16·80	"	"	"	35 "	10·17	17·53	31·67	24·34	"
Oct. 2	11.30 a.m.	31 "	12.95	½ flood.	North .	"	Surface.	10·52	17·01	30·73	23·56	Gre'nish.
" 2	11.50 "	31 "	12·95	"	"	"	10 m.	10·18	17·03	30·77	23·65	Gray.
" 2	11.30 "	31 "	12·95	"	"	"	20 "	10·12	17·31	31·27	24·06	"
" 2	11.30 "	31 "	12·95	"	"	"	30 "	10·11	17·45	31·54	24·25	"
" 9	7.50 "	33 "	11·72	2 hours to high tide.	N.-E. breeze.	Cloudy rain.	Surface.	10·31	No water sample.			Grayish.
" 9	7.50 "	33 "	11·72	"	"	"	20 m.	10·04	"	"		"
" 9	7.50 "	33 "	11·72	"	"	"	30 "	10·01	"	"		"
" 16	4.11 p.m.	35 "	14·21	1 hour ebb..	Moderate N.-W.	partly cloudy.	Surface.	9·42	Sample lost.			Gre'nish.
" 16	4.11 "	35 "	14·21	"	"	"	20 m.	9·16	"	"		"
" 16	4.11 "	35 "	14·21	"	"	"	30 "	9·12	"	"		"
" 21	9.37 a.m.	31 "	13·91	2¼ hours ebb.	Fresh S.-W.	Misty. Clouds.	Surface.	9·47	No water sample.			Grayish.
" 21	9.37 "	31 "	13·91	"	"	"	10 m.	9·06	"	"		"
" 21	9.37 "	31 "	13·91	"	"	"	20 "	8·90	"	"		"
" 21	9.37 "	31 "	13·91	"	"	"	30 "	8·88	"	"		"

SAMPLES

"Prince" Stations No.	Locality.	Position (vide chart.)	Latitude.	Longitude.	Bottom.
6	Ste Croix River between Biological station and Robbinston.	Biological station bears E ¾ S. 6/10 of a mile. Little Dochet Id. bears N. by W. ½ W. 2¾ miles.	45° 4' 49" N...	67° 5' 53" W..	Fairly hard mud.
6	" "	" "	"	"	"
6	" "	" "	"	"	"
6	" "	" "	"	"	"
7	" "	" "	"	"	"
7	" "	" "	"	"	"
8	Bay of Fundy, east of White Horse Id., just south of Letite Passage.	Head Harbour Lt. bears S.-W. by W., 2⅞ miles. Green's Point Lt. bears N. by W. 2⅞ miles.	44° 59' 47" N..	66° 51' 24" W.	Sand and mud.
8	" "	" "	"	"	"
8	" "	" "	"	"	"
8	" "	" "	"	"	"
9	Passamaquoddy Bay, off Clam Cove Head.	Forest Id. bears S.-W. ¼ mile. Southern end of Clam Cove Head bears S. S.-E. ⅞ miles.	44° 58' 39" N..	67° 2' 7" W...	Sand, mud and shells.
9	" "	" "	"	"	"
9	" "	" "	"	"	"
9	" "	" "	"	"	"
9	" "	" "	"	"	"
9	" "	" "	"	"	"
9	" "	" "	"	"	"
9	" "	" "	"	"	"
9	" "	" "	"	"	"
9	" "	" "	"	"	"
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9	" "	" "	"	"	"

COLLECTED—*Con.*

Date.	Hour.	Depth in metres.	Air temperature t° C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Water temperature t° C.	Chlorine Cl.	Salinity S. ‰.	Density σt.	Colour of water.
1916.												
Oct. 27	10.25 "	34 "	7·38	1¼ hours to high tide.	Moderate. N.-W.	Clear. .	Surface.	8·90	No water sample.			Gre'n-ish Gray.
" 27	10.25 " .	34 "	7·38	"	"	" ..	20 m.	8·82	"	"		"
" 27	10.25 " .	34 "	7·38	"	"	" ..	30 "	8·82	"	"		"
....	....	84 "	..	......	......	....	.....	.	..	....	......	. .
....	.....	84 "	... .	....	.... .	...	. .	... .	.....	... .	.. .	...
July 14	5.00 p.m..	73 "	12·15	... ...	. .	......	9 m.	7·62	17·33	31·32	24·47	. . .
....	. .....	. . .	....	. ....	....	... ...	......	....		....	.	......
......	....	.....	. .	.... . .	.. .	. ....	.....	.....	.	.....	.....	.
.....	. .....	. . .	.	.. . .	....	....	.. .	....		. .	...	.
Aug 3	3.00 p.m..	73 m.	15·05	High. .	S.-W. breeze.	Cloudy.	Surface.	9·50	17·06	30·82	23·81	. . .
" 3	3.00 " .	73 "	15·05	" ...	"	"	10 m.	9·10	17·11	30·92	23·95	..
" 3	3.00 "	73 "	15·05	"	"	"	20 "	8·95	17·18	31·04	24·08	. ...
" 3	3.00 "	73 "	15·05	" .	"	"	30 "	8·60	17·26	31·19	24·23	.....
" 3	3.00 " .	73 "	15·05	"	"	"	40 "	8·42	17·32	31·29	24·33	.
" 10	12.45 "	72 "	22·20	Low tide ..	very slight S. breeze.	Clear.	Surface.	12·62	16 18	29·24	22·16	....
" 10	12.45 " .	72 "	22·20	" ...	"	"	10 m.	10·02	16·99	30·71	23·62	..
" 10	12.45 " .	72 "	22·20	" .	"	"	20 "	9·20	17·23	31 13	24·09	.....
" 10	12.45 " .	72 "	22·20	" ..	"	"	30 "	9·12	17·25	31·16	24 13	....
" 10	12.45 "	72 "	22·20	" ..	"	"	40 "	9·12	17·25	31 16	24·13	. .
" 17	3.50 " .	72 .	18·30	1½ hour ebb.	Calm...	"	Surface.	10·05	17·36	31·36	24 14	..
" 17	3.50 "	72 "	18·30	"	"	"	10 m.	9·57	17·36	31·36	24·14	. . .
Aug. 17	4.00 p.m.	72 m.	18·30	1½ hr. ebb.	Calm.	Clear.	20 m.	9·48	17·38	31·40	24·24	
" 17	4.00 "	72 "	18·30	"	"	"	30 m.	9·02	17·47	31·57	24·46	
" 17	4.00 "	72 "	18·30	"	"	"	40 m.	9·01	17·47	31·57	24.46	
Aug. 31	2.00 "	78 m.	16·68	¾ hr. ebb.	S.W. breeze.	"	Surface.	12·21	17·06	30 82	23·34	
" 31	2.00 "	78 "	16·68	"	"	"	20 m.	10·16	17·45	31 54	24·25	
" 31	2.00 "	78 "	16 68	"	"	"	75 m.	9·81	17·53	31·67	24·46	
Sept. 15	3.26 "	76 m.	14·80	½ hr. ebb.	S.E. breeze.	Hazy.	Surface.	10·42	17·24	31·16	23·89	Gray.
" 15	3.26 "	76 "	14·80	"	"	"	10 m.	10·11	17·58	31·75	24·44	"
" 15	3.26 "	76 "	14 80	"	"	"	20 m.	10·12	17·57	31·74	24·44	"
" 15	3 26 "	76 "	14·80	"	"	"	30 m.	10 11	17·59	31·78	24·45	"
" 15	2.51 "	76 "	14 80	"	"	"	40 m.	10·02	17·79	32 15	24·75	"
" 15	2.51 "	76 "	14·80	"	"	"	50 m.	9·85	17 27	31·21	24·05	"
" 15	3.15 "	76 "	14·80	"	"	"	60 m.	9·92	17·42	31 47	24·25	"
" 15	3.15 "	76 "	14 80	"	"	"	70 m.	9·92	17·62	31·84	24·53	"
" 15	3.15 "	76 "	14·80	"	"	"	75 m.	9·93	17·80	32·16	24·78	"
Oct. 3	11 49 a.m.	75 m.	14·56	1 hr. flood.	S.W. light breeze.	Clear.	Surface.	10·61	17·40	31·45	24·12	Gre'n-ish.

SAMPLES

"Prince" Stations. No.	Locality.	Position (vide chart).	Latitude.	Longitude.	Bottom.
9	Passamaquoddy Bay, off Clam Cove Head.	Forest Id. bears S.W. ¾ mile. Southern end of Clam Cove Head bears S.S.E. ⅞ mile.	44° 58′ 39″ N.	67° 2′ 7″ W.	Sand, mud and shells.
9....	" "	" "	"	"	"
9 .	" "	" "	"	"	"
9	" "	" "	"	"	"
9	" "	" "	"	"	"
9...	" "	" "	"	"	"
9	" "	" "	"	"	"
9 . .	" "	" "	"	"	"
9	" "	" "	"	"	"
10	Passamaquoddy Bay, near Eastern entrance to St. Andrew's Harbour.	Navy Bar Lt. bears N.W. by N. ½ N., ⅜ mile. Tongue Shoal Lt. bears E. by N. ¾ N., ⅞ mile.	45° 3′ 14″ N.	67° 1′ 45″ W.	Mud and rocks.
10 .	" "	" "	"	"	"
10........	" "	" "	"	"	"
10.......	" "	" "	"	"	"
10	" "	" "	"	"	"
10 . .	" "	" "	"	"	"
10........	" "	" "	"	"	"
10	" "	" "	"	"	"
10....	" "	" "	"	"	"
10. . ..	" "	" "	"	"	"
10.... .	" "	" "	"	"	"
10.	" "	" "	"	"	"
10 . .	" "	" "	"	"	"
10 . .	" "	" "	"	"	"
10	" "	" "	"	"	"
10..	" "	" "	"	"	"
10...... .	" "	" "	"	"	"
10.. . ..	" "	" "	"	"	"
10........	" "	" "	"	"	"
10	" "	" "	"	"	"
10 ..	" "	" "	"	"	"
10	" "	" "	"	"	"
10..	" "	" "	"	"	"
10	" "	" "	"	"	"
10..	" "	" "	"	"	"
10... .	" "	" "	"	"	"
10.... ...	" "	" "	"	"	"

SESSIONAL PAPER No. 38a

COLLECTED—*Con.*

Date.	Hour.	Depth in Metres.	Air Temperature t° C.	Tide.	Wind.	Sky.	Depth in determinations metres.	Water Temperature t° C.	Chlorine. Cl. ‰	Salinity. S ‰	Density. σt.	Colour of Water.
1916.												
Oct 3	11.49 a.m.	75 m.	14·56	1 hr. flood.	S. W. light breeze.	Clear.	10 m.	10·20	17·52	31 65	24 34	Gray
„ 3	11.49 „	75 „	14 56	„	„	„	20 m.	10·12	17·19	31·07	23·88	„
„ 3	11.49 „	75 „	14·56	„	„	„	30 m.	9·98	17 54	31 70	24 40	„
„ 3	11 35 „	75 „	14 56	„	„	„	40 m.	9·85	sampl	e lost.	. . .	„
Oct. 3	11.35 „	75 m.	14 56	1 hr. flood.	S.W. light breeze.	„	50 m.	9·83	17·64	31·88	24·58	Gre'n-ish.
„ 3	11.35 „	75 „	14.56	„	„	„	75 m.	9·68	17·71	32·00	24 70	Gray
Oct. 17	8.32 „	76 m.	11·61	1½ hr. to low tide.	Strong S.W.	Cloudy; rain.	Sur-face.	9·10	No	water.		
„ 17	8.32 „	76 „	11·61	„	„	„	20 m.	9·01		„		
„ 17	8.32 „	76 „	11 61	„	„	„	75 m.	8·91		„		
Aug. 3	5.00 p.m.	20 m.		2¼ hrs. ebb tide.	S.W. breeze.	Cloudy.	Sur-face.	10·70	16·77	30·30	23·21	
„ 3	5.00 „	20 „	.	„	„	„	10 m.	8·95	17 13	30·96	23·99	
„ 3	5.00 „	20 „	. . .	„	„	„	20 m. (bot tom.)	8·75	17·18	31·04	24 09	
Aug. 17	6.10 „	18 m.	15·12	2 hrs. to low tide.	.	Slight haze.	Sur-face.	11·75	17 07	30 84	23 43	
„ 17	6.10 „	18 „	15·12	„	„	„	10 m.	10·18	17·18	31 04	23 89	
„ 17	6 10 „	18 „	15 12	„	„	„	15 m.	10·19	17·23	31·13	23·94	
Aug 24	3.45 „	16 m.	17·28	Low tide.	Light E.	Rain.	Sur face.	13·70	No	water.		
„ 24	3.45 „	16 „	17·28	„	„	„	10 m.	9·72		„		
„ 24	3.45 „	16 „	17·28	„	„	„	15 m.	9·61		„		
Aug. 31	11.25 a.m.	21 m.	16·89	2 hrs. to high tide.	Calm.	Clear.	Sur-face.	12·20	17·18	31 05	23 51	
„ 31	11.25 „	21 „	16·89	„	„	„	15 m.	10·19	17 43	31·49	24·22	
„ 31	11.25 „	21 „	16 89	„	„	„	20 m.	10·09	17·48	31·59	24·30	
Sept. 15	10.41 „	20 m.	16·58	2½ hrs. flood.	Light S.E. breeze.	„	Sur-face.	11·42	17·41	31·46	23·97	Gray.
„ 15	10.41 „	20 „	16·58	„	„	„	10 m.	10·24	17·46	31·55	24·25	„
Oct. 3	9.05 „	17 m.	10.98	1 hr. to low tide.	N.W. mode rate.	„	Surf.	10·51	17·36	31 36	24 06	„
„ 3	9.05 „	17 „	10.98	„	„	„	10 m.	10·38	17·52	31·66	24 30	„
„ 3	9.05 „	17 „	10 98	„	„	„	15 m.	9·72	17·53	31·67	24 42	„
„ 9	9.33 „	22 „	10.90	High tide.	N.E.	cloudy.	Surf.	10·20	no	water.		„
„ 9	9.33 „	22 „	10 90	„	„	„	10 m.	9 83		„		„
„ 9	9.33 „	22 „	10 90	„	„	„	20 m.	9 85		„		„
„ 16	11.09 „	19 „	11.12	2 hrs. flood.	S.W. mode rate.	„	Surf.	9·24	17·64	31·88	24 64	Gre'n-ish Gray.
„ 16	11.09 „	19 „	11 12	„	„	„	13 m.	9·12	17·70	31·99	24·77	„
„ 16	11 09 „	19 „	11 12	„	„	„	18 m.	9·12	17 69	31·96	24·76	„
„ 21	12.52 p.m.	18 „	13.45	1 hr. to low tide.	Strong S.W.	clouds, rain.	Surf.	9.30	no	water.		Gray-ish.
„ 21	12.52 „	18 „	13.45	„	„	„	10 m.	8 95		„		„
„ 21	12 52 „	18 „	13 45	„	„	„	17 m.	8·86		„		„
„ 27	8.08 a.m.	19 „	4.62	2½ hrs. flood.	Mode-rate.	partly cloudy.	Surf.	8·64		„		Gre'n-ish Gray.

SAMPLES

"Prince" Station No.	Locality.	Position (vide chart.)	Latitude.	Longitude.	Bottom.
10	Passamaquoddy Bay, near Eastern entrance to St. Andrews Harbour.	Navy Bar Lt. bears N.W. by N½ N. ⅜ mile. Tongue Shoal Lt bears E. by N. ¾ N., ⅞ mile.	45° 3′ 14″ N.	67° 1′ 45″ W.	Mud and rocks.
10	" "	" "	"	"	"
10	" "	" "	"	"	"
11	Petite Passage	In a direct line between Tiverton and East Ferry about midway.	44° 23′ 52″ N.	66° 12′ 34″ W.	Hard sand and rocks.
11	"	" "	"	"	"
11	"	" "	"	"	"
11	"	" "	"	"	"
11	"	" "	"	"	"
11	"	" "	"	"	"
11	"	" "	"	"	"
11	"	" "	"	"	"
12	St. Mary's Bay, off Little River.	One mile S.E. from Little River wharf.	44° 26′ 17″ N	66° 6′ 33″ W.	Fine sand.
12	" "	" "	"	"	"
12	" "	" "	"	"	"
12	" "	" "	"	"	"
12	" "	" "	"	"	"
12	" "	" "	"	"	"
12	" "	" "	"	"	"
13	St. Mary's Bay, below Southern end of Petite Passage.	South Point of Digby neck bears N.E. ½ N. 2¼ miles. Church Pt. bears E. by S. ¾ S. 4¼ miles.	44° 20′ 7″ N.	66° 13′ 24″ W.	"
13	" "	" "	"	"	"
13	" "	" "	"	"	"
13	" "	" "	"	"	"
13	" "	" "	"	"	"
13	" "	" "	"	"	"
15	Bay of Fundy, off Brier Island.	8¾ miles N.-W. by W. from north end of Grande Passage. Run N. N.W. 4 miles, then run W. ½ N., 5¼ miles.	44° 19′ 30″ N.	66° 32′ 28″ W.	Fine sand.
15	" "	" "	"	"	"
15	" "	" "	"	"	"
15	" "	" "	"	"	"
15	" "	" "	"	"	"
15	" "	" "	"	"	"
15	" "	" "	"	"	"
15	" "	" "	"	"	"
15	" "	" "	"	"	"
15	" "	" "	"	"	"
15	" "	" "	"	"	"

COLLECTED—*Con.*

Date.	Hour.	Depth of Metres.	Air temperature t° C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Water temperature t° C.	Chlorine Cl. °/oo.	Salinity S.	Density σt.	Colour of Water.
1916.												
Oct. 27	8.08 a.m.	19 m.	4.62	hrs. flood.	N.W.	cloudy.	13 m.	8 92	no	water.		Gray.
" 27	8.08 "	19 "	4.62	"	"	"	18 m.	8·87		"		"
Sept. 2	7.55 "	30 "	13.02	Low tide.	South breeze.	cloudy.	Surf.	9·00	17·91	32·37	25·08	
" 2	7.55 "	30 "	13.02	"	"	"	10 m.	8·91	17·94	32·41	25·14	
" 2	7.55 "	30 "	13.02	"	"	"	20 m.	8·91	17·89	32·32	25·07	
" 2	7.55 "	30 "	13.02	"	"	"	25 m.	8.42	17·89	32·32	25.13	
" 2	1.15 p.m.	35 "	15.28	High tide.	Strong south.	cloudy	Surf.	10·57	17·73	32·03	24·59	Bluish.
" 2	1.15 "	35 "	15.28	"	"	"	10 m.	10·32	17·79	32·15	24·70	"
" 2	1.15 "	35 "	15.28	"	"	"	20 m.	10·21	17·81	32·18	24·75	"
" 2	1.15 "	35 "	15.28	"	"	"	30 m.	10·13	17·79	32·15	24 75	"
" 4	8.50 a.m.	24 "	13.38	Low tide.	S.W.N. breeze.	clear.	Surf.	12·92	17·70	31·98	24·10	"
" 4	8.50 "	24 "	13 38	"	"	"	10 m.	12·92	17·70	31·99	24·10	"
" 4	8.50 "	24 "	13.38	"	"	"	20 m.	11·51	17·76	32·09	24·46	"
" 4	3.10 p.m.	31 "	12.20	High tide.	S.W. breeze.	cloudy.	Surf.	12·58	17·67	31·93	24·13	Grayish.
" 4	3.10 "	31 "	12.20	"	"	"	10 m.	12·51	17·68	31·95	24·15	"
" 4	3.10 "	31 "	12.20	"	"	"	20 m.	11 12	17·73	32·03	24·49	"
" 4	3.10 "	31 "	12.20	"	"	"	30 m.	11 04	17·77	32·10	24·55	"
" 5	10.27 a.m.	50 "	11.90	Low tide.	N.E. breeze.	"	Surf.	11·08	17·74	32·05	24 51	Grayish.
" 5	10.41 "	50 "	11.90	"	"	"	10 m.	10·14	17·83	32·21	24·79	"
" 5	10.41 "	50 "	11 90	"	"	"	20 m.	9·82	17·85	32·26	24·86	"
" 5	10.27 "	50 "	11.90	"	"	"	30 m.	9·60	17·86	32·28	24·93	"
" 5	10.27 "	50 "	11.90	"	"	"	40 m.	9·18	17·91	32·36	25·05	"
" 5	10.27 "	50 "	11.90	"	"	"	48 m.	9·09	17·93	32·40	25 12	"
Sept. 6	11.45 a.m..	203 m.	14·80	Low tide...	Calm...	Cloudy	Surface.	9·17	17 98	32·48	25·15	Dark blue.
" 6	12.15 p.m..	203 "	14·80	" ...	" ...	"	10 m.	8·58	18·00	32·52	25·25	"
" 6	12.15 " .	203 "	14·80	" ...	" ...	"	20 "	8·40	18·01	32·54	25·31	"
" 6	12.15 "	203 "	14 80	" ...	" ...	"	25 "	8·31	18·02	32 55	25·33	"
" 6	12.15 " .	203 "	14 80	. .	" ...	"	50 "	8·15	18·03	32·56	25 37	"
" 6	12.10 "	203 "	14·80	" ...	" ...	"	75 "	7·78	18 05	32·61	25·46	"
" 6	12.00 noon.	203 "	14·80	" ...	" ...	"	100 "	7·49	18 10	32·71	25·53	"
" 6	11.45 a.m..	203 "	14·80	" ...	" ...	"	125 "	6·28	18·19	32·87	25·85	"
" 6	11.45 " .	203 "	14·80	" ...	" ...	"	150 "	5·88	18·22	32·91	25·97	"
" 6	11.45 " .	203 "	14·80	" ...	" ...	"	175 "	5·57	18·24	32 96	26·03	"
" 6	11.45 "	203 "	14·80	" ..	" ...	"	200 "	5·55	18·72	32·74	25·57	"

SAMPLES

"Prince" Stations No.	Locality.	Position (vide chart.)	Latitude.	Longitude.	Bottom.
16	Gulf of Maine, outside Yarmouth Harbour.	Beside Yarmouth. N.-W. Fairway buoy.	43° 48′ 48″ N.	66° 15′ 54″ W.	Hard rocks and gravel
16	" "	" "	"	"	"
16	" "	" "	"	"	"
16	" "	" "	"	"	"
16		" "	"	"	"
16	" "	" "	"	"	"
16	" "	" "	"	"	"
16	" "	" "	"	"	"
16	" "	" "	"	"	"
16	" "	" "	"	"	"
16	" "	" "	"	"	"
17	Yarmouth Harbour	¼ mile outside Bunker Id. red light. Abreast lower end of Ship's Stern.	43° 48′ 13″ N.	66° 8′ 42″ W.	Soft mud
17	" "	" "	"	"	"
17	" "	" "	"	"	"
17	" "	" "	"	"	"
17	" "	" "	"	"	"
17	"	" "	"	"	"
18	St. John River, between Fairville and Indiantown.	About 100 yds. off east corner of Lovett's Pt. toward Marble Cove Pt.	45° 16′ 38″ N.	66° 5′ 53″ W.	Rocks and sawdust.
18	" "	" "	"	"	"
18	" "	" "	"	"	"
18	" "	" "	"	"	"
18	" "	" "	"	"	"
19	Bay of Fundy, off St. John Harbour.	Partridge Id. bell boat bears N.E. by N. ¼ N. 2½ miles. Eastern end of Meogenes Id. bears N.-W. by N. 2⅛ miles.	45° 12′ 11″ N.	66° 3′ 40″ W.	Soft mud
19	" "	" "	"	"	"
19	" "	" "	"	"	"
20	Kennebecasis Bay, at western end of Long Id.	Milkish Head bears N. by W. ½ W. ½ mile. Outside point of Long Id. bears N.-E. by E. ¼ E. by 1¼ miles.	45° 20′ 57″ N.	66° 4′ 8″ W.	"
20	" "	" "	"	"	"
20	" "	" "	"	"	"
20	" "	" "	"	"	"
20	Kennebecasis Bay, at Western end of Long Id.	Milkish head bears N. by W. ½ W. ½ mile. Outside point of Long Id. bears N. E. by E. ¼ E. 1¼ miles.	45° 12 57″ N.	66° 4′ 8″ W.	"
20	" "	" "	"	"	"
20	" "	" "	"	"	"
20	" "	" "	"	"	"
20	"	" "	"	"	"
21	Kennebecasis Bay, at eastern end of Long Id.	Outside point of Long Id. bears S.W. by S. ¼ S., 1 mile. Northern end of Long Id. bears N,N.W.	45° 24′ 44″ N.	66° 1′ 43″ W.	"
21	" "	" "	"	"	"
21	" "	" "	"	"	"
21	" "	" "	"	"	"
21	" "	" "	"	"	"
21	" "	" "	"	"	"
21	" "	" "	"	"	"

COLLECTED—*Con.*

Date.	Hour.	Depth in metres.	Air temperature t °C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Water temperature t °C.	Chlorine Cl.	Salinity S.	Density σt.	Colour of water.
1916. Sept. 7	12.40 p.m.	41 m.	16·68	Low tide..	Calm..	Foggy..	Surface.	10·03	17·85	32 25	24 84	„
„ 7	12.50 „	41 „	16·68	„	„	„	10 m.	9 82	17·60	31·81	24·53	„
„ 7	12.50 „	41 „	16 68	„	„	„	20 „	9·78	17·39	31·42	34 24	„
„ 7	12.50 „	41 „	16·68	„	„	„	30 „	9·72	16·22	29 32	22·59	„
„ 7	12.50 „	41 „	16·68	„	„	„	40 „	9·69	17·21	31 09	23 99	„
„ 9	7.45 a.m..	47 „	12 52	¼ hour to high tide.	„	Fog and rain.	Surface.	9·40	18.06	32·63	25·23	Grayish.
„ 9	8 04 „	47 „	12·52	„	„	„	10 m.	9·21	17·75	32·07	24 83	„
„ 9	8.04 „	47 „	12·52	„	„	„	20 „	9·12	17·42	31·47	24·37	„
„ 9	7.45 „	47 „	12·52	„	„	„	30 „	9·20	17·59	31·78	24·61	„
„ 9	7.45 „	47 „	12·52	„	„	„	40 „	9·18	17 58	31·76	24 58	„
„ 9	7.45 „	47 „	12·52	„	„	„	45 „	9·18	17·89	32·33	25·02	„
„ 8	6.20 „	15 „	13·70	High tide..	South...	Thick Fog.	Surface.	11·32	17·25	31·17	23·77	„
„ 8	6.20 „	15 „	13·70	„	„	„	10 m.	10·83	17·54	31·69	24 27	„
„ 8	6.20 „	15 „	13·70	„	„	„	15 „	10·82	Water	sampl	e lost.	„
„ 8	1.20 p.m..	13 „	14·25	Low tide...	S.-W. breeze.	Foggy.	Surface.	12·70	17 78	32·12	24 25	„
„ 8	1.20 „	13 „	14·25	„	„	„	10 m.	11·78	17·53	31·68	24 09	„
„ 8	1.20 „	13 „	14·25	„	„	„	13 „	11·56	17 54	31·69	24·15	„
„ 21	4.13 „	35 „	16 35		Light S.-W.	Smoky.	Surface.	14 80	Water	sampl	e lost.	Bro'n.
„ 21	4.13 „	35 „	16 35		„	„	10 m.	13 19	8·36	15·13	10·55	„
„ 21	4.13 „	35 „	16 35		„	„	20 „	11·91	Water	sampl	e lost.	„
„ 21	4.13 „	35 „	16 35		„	„	30 „	11·55	14 36	25 96	19·71	„
„ 21	4.25 „	35 „	16·35		„	„	34 „	9·28	14 55	26 30	20 31	„
„ 19	10.39 a.m..	19 „	12·25	½ hr. to low tide.	„	Cloudy.	Surface.	11·78	Water	sampl	e lost.	Green
„ 19	10.39 „	19 „	12 26	„	„	„	10 m.	10 62	17·03	30 78	23·57	„
„ 19	10.39 „	19 „	12 26	„	„	„	19 m.	10 59	Water	sampl	e lost.	„
„ 19	4.00 p.m..	55 „	11 80	1 hour river flood.	Light N.-W. breeze.	Clear...	Surface.	15·69	„		„	Bro'n.
„ 19	4.20 „	55 „	11 80	„	„	„	5 m.	12 93	„		„	„
„ 19	4.10 „	55 „	11·80	„	„		10 „	6·08	„		„	„
„ 19	4.20 „	55 „	11 80	„	„	„	15 „	6·43	„		„	„
Sept. 19	4.10 p.m.	55 m.	11·80	1 hr. river flood.	Light N.W. breeze.	clear.	20 m	8·22	10 61	19·18	14·92	Bro'n.
„ 19	3.55 „	55 „	11·80	„	„	„	30 m.	10 98	water	sampl	e lost.	„
„ 19	3.55 „	55 „	11 80	„	„	„	40 m.	11·74		„		„
„ 19	3 55 „	55 „	11·80	„	„	„	44 m.	11·93		„		„
„ 19	4.40 „	55 „	11·80	„	„	„	55 m.	12·00		„		„
„ 20	3.40 „	48 „	16·10	...	N.W. breeze.	„	Surface.	15·38		„		„
								7·20	10 15	18·35	14 38	„
„ 20	3.50 „	48 „	16·10		„	„	10 m.	6·11	11·13	20·13	15 86	„
„ 20	3.50 „	48 „	16 10	...	„	„	20 m.	10·18	11 53	20·85	15·95	„
„ 20	3.40 „	48 „	16·10		„	„	30 m.	11 15	11·69	21·14	16·03	„
„ 20	3.40 „	48 „	16·10	...	„	„	40 m.	11·21	water	sampl	e lost.	
„ 20	3.40 „	48 „	16 10	...	„	„	45 m.	16·10		„		Bro'n.
„ 21	2.48 „	11 „	17·54		S.S.E. breeze.	Hazy.	Surface.	13·67	8·64	15·63	11 4	„

SAMPLES

"Prince" Stations No.	Locality.	Position (vide chart.)	Latitude.	Longitude.	Bottom.
22	St. John River, near mouth of Kennebecasis Bay.	West end of Milkish Id. bears E.N.E. Point on south side of mouth of Kennebecasis Bay bears S.S.E.	45° 18′ 30″ N.	66° 9′ 32″ W.	Soft mud.
22	" "	" "	"	"	"
22	" "	" "	"	"	"
23	Bay of Fundy, between St. John and Digby.	15 miles south of Partridge Id. bell boat. 20 miles north of Prim point.	45° 0′ 18″ N.	65° 56′ 10″ W.	Sand and gravel.
23	" "	" "	"	"	"
23	" "	" "	"	"	"
23	" "	" "	"	"	"
23	" "	" "	"	"	"
23	" "	" "	"	"	"
23	" "	" "	"	"	"
23	" "	" "	"	"	"
23	" "	" "	"	"	"
24	Lower end of Annapolis Basin.	Port Wade pier bears E.N.E. Outside point of Victoria Beach bears N. ½ W.	44° 39′ 15″ N.	65° 44′ 22″ W.	Fine sand.
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
24	" "	" "	"	"	"
25	Bay of Fundy, off Digby Gut.	⅞ mile N.W. ½ N. from Fairway Buoy, 1⅜ mile N. by E. ½ E., from Point Prim.			
25	" "	" "	44° 43′ 17″ N.	65° 47′ 18″ W.	Sand and shells.
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"
25	" "	" "	"	"	"

COLLECTED—*Con.*

Date.	Hour.	Depth in metres.	Air temperature t° C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Water temperature t° C.	Chlorine Cl.	Salinity S. ‰.	Density σt.	Colour of water.
1916.												
Sept 21	2.43 p.m.	11 m.	17·54	.	S.E. breeze.	Hazy.	5 m.	11·70	water	sampl	e lost.	"
" 21	2.43 "	11 m.	17·54	....	"	"	10 m.	. .		. . . .		.
....	.....	...	.....	....	.....	.....	....	.	.			...
Sept. 22	12.43 p.m.	95 m.	17·74	1½ hr. to low tide.	Calm.	Clear.	Surface.	10·30	17·36	31·37	24·09	Blue.
" 22	1.07 "	95 "	17·74	"	"	"	10 m.	9·56	17·74	32·06	24·76	"
" 22	1.07 "	95 "	17·74	"		"	20 m.	8·83	17·85	32·25	25·04	"
" 22	12.56 "	95 "	17·74	"	"	"	25 m.	8·73	17·89	32·32	25·09	"
" 22	12.56 "	95 "	17·74	"	"	"	30 m.	8·57	17·93	32·40	25·18	"
" 22	12.56 "	95 "	17·74	"	"	"	40 m.	8·38	17·95	32·44	25·24	"
" 22	12.43 "	95 "	17·74	"	"	"	50 m.	8·12	17·96	32·46	25·28	"
" 22	12.43 "	95 "	17·74	"	"	"	75 m.	7·93	18·01	32·55	25·38	"
" 22	12.43 "	95 "	17·74	"	"	"	95 m.	7·90	18·03	32·58	25·42	"
" 23	9.19 a.m.	58 "	12·83	High tide.	Light S.E. breeze.	cloudy.	Surface.	9·37	17·86	32·28	24·95	Gre'n-ish.
" 23	9.43 "	58 "	12·83	"	"	"	10 m.	9·32	water	sampl	e lost.	Gray.
" 23	9.33 "	58 "	12·83	"	"	"	20 m.	9·31	17·94	32·41	25·07	"
" 23	9.33 "	58 "	12·83	"	"	"	25 m.	9·28	17·93	32·39	25·07	"
" 23	9.33 "	58 "	12·83		"	"	30 m.	9·29	17·93	32·39	25·07	"
" 23	9.19 "	58 "	12·83	"	"	"	40 m.	9·30	17·96	32·45	25·10	"
" 23	9.19 "	58 "	12·83	"	"	"	50 m.	9·28	17·33	31·32	24·22	"
" 23	9.19 "	58 "	12·83	"	"	"	55 m.	9·29	17·89	32·33	25·01	"
" 23	5.52 p.m.	55 "	15·58	Low tide.	S.W. breeze.	clear.	Surface.	10·48	17·91	32·37	24·84	Gray-ish.
" 23	5.49 "	55 "	15·58	"	"	"	10 m.	10·37	17·87	32·29	24·80	"
" 23	5.49 "	55 "	15·58	"	"	"	20 m.	10·30	water	sampl	e lost.	"
" 23	5.37 "	55 "	15·58	"	"	"	30 m.	10·22		"		"
" 23	5.37 "	55 "	15·58	"	"	"	40 m.	10·18	17·31	31·28	24·05	"
" 23	5.37 "	55 "	15·58	"	"	"	50 m.	9·86	17·23	31·13	24·00	"
Sept. 23	2.16 p.m.	74 m.	15·95	½ hour to low tide.	S.E. breeze.	Cloudy.	Surface.	9·30	17·95	32·44	25·10	Gre'n-ish.
" 23	2.45 "	74 "	15·95	"	"	"	10 m.	9·08	17·97	32·47	25·16	Gray.
" 23	2.33 "	74 "	15·95	"	"	"	20 m.	9·08	17·45	31·54	24·42	"
" 23	2.33 "	74 "	15·95	"	"	"	25 m.	9·07	17·57	31·75	24·58	"
" 23	2.33 "	74 "	15·95	"	"	"	30 m.	9·09	17·96	32·46	25·13	"
" 23	2.18 "	74 "	15·95	"	"	"	40 m.	9·02	17·92	32·38	25·09	"
" 23	2.18 "	74 "	15·95	"	"	"	50 m.	9·02	17·98	32·48	25·17	"
" 23	2.18 "	74 "	15·95	"	"	"	73 m.	9·03	17·95	32·43	25·14	"
Sept. 27	12.18 "	75 "	12·19	High tide.	S.W. breeze.	Hazy.	Surface.	9·21	Water	sampl	e lost.	Gre'n-ish.
" 27	12.31 "	75 "	12·19	"	"		10 m.	9.17		"	"	Blue.
" 27	12.18 "	75 "	12·19	"	"	"	20 m.	9·18		"	"	"
" 27	12.18 "	75 "	12·19	"	"	"	25 m.	9·13	17·40	31·45	24·34	"
" 27	12.18 "	75 "	12·19	"	"	"	30 m.	9·16	17·40	31·44	24·34	"
" 27	12.02 "	75 "	12·19	"	"	"	40 m.	9·14	17·85	32·25	24·98	"
" 27	12.02 "	75 "	12·19	"	"	"	50 m.	9·13	17·62	31·84	24·65	"
" 27	12.02 "	75 "	12·19	"	"	"	74 m.	9·13	Water	sampl	e lost.	"

SAMPLES

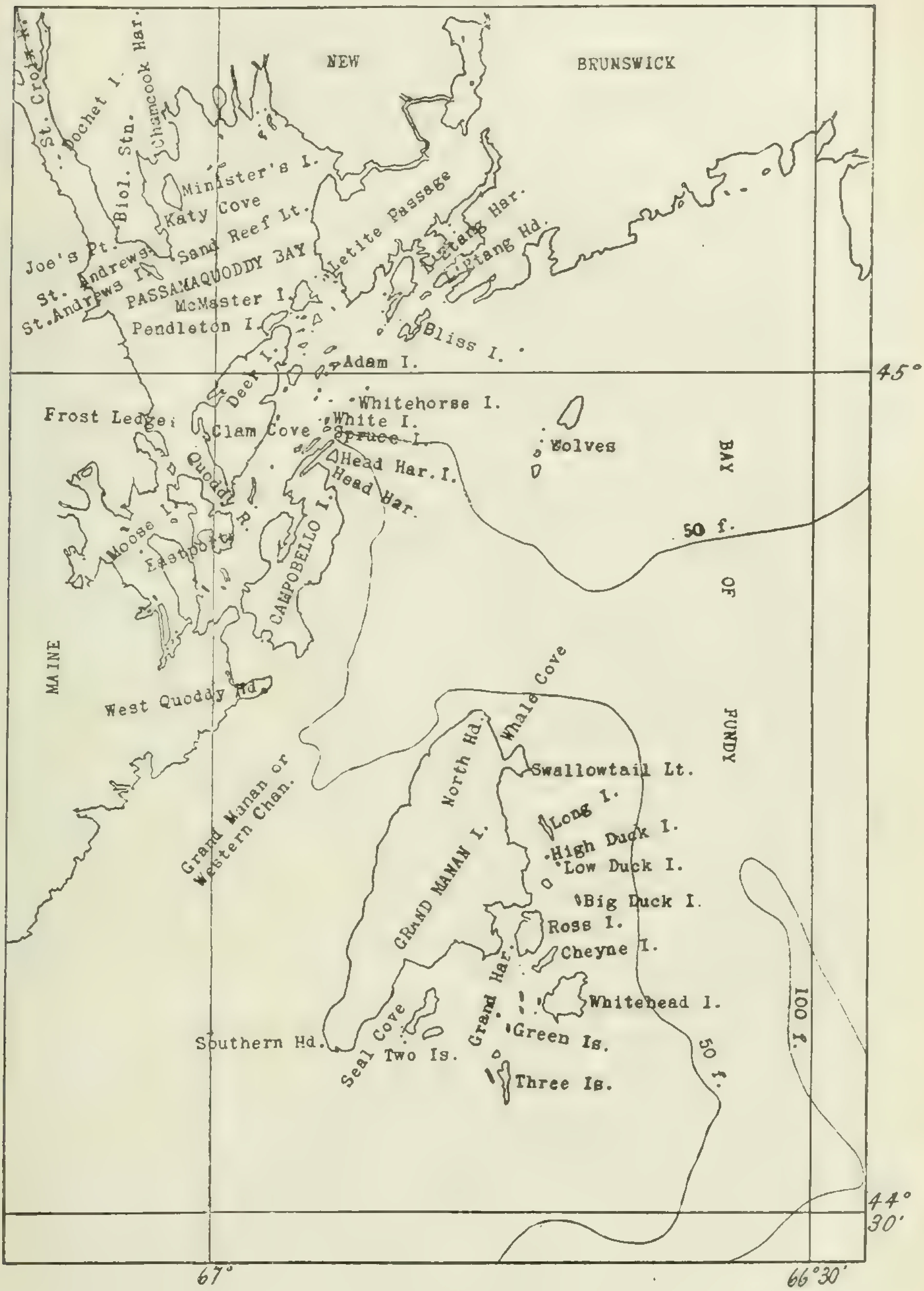
"Prince" Stations No.	Locality.	Position (vide chart.)	Latitude.	Longitude.	Bottom.
26	Basin in River, inside Annapolis Royal.	Lighthouse in bend above Granville Ferry bears N. by W. ½ W. First point on south side above basin bears E.	44° 44′ 55″ N.	65° 29′ 52″ W.	Very soft mud.
26....	" "	" "	"	"	"
26	" "	" "	"	"	"
26....	" "	" "	"	"	"
26 ...	" "	" "	"	"	"
26........	" "	" "	"	"	"
27	Annapolis River, northern passage, around Goat Island.	Lighthouse on Shaffner's Point bears N.E. ½ E. Western side of Goat Id. bears S.E. by S. ½ S.			
27	" "	" "	44° 42′ 21″ N.	65° 37′ 29″ W.	Soft mud.
27......	" "	" "	"	"	"
27....	" "	" "	"	"	"
27 ..	" "	" "	"	"	"
	Briar Island to Yarmouth.	3 miles	......	......	......
		5 "	......	......	......
		8 "	......	......	......
		11 "	......	......	......
		14 "	......	......	......
		17 "	......	......	......
		20 "	......	......	......
		23 "	......	......	......
		26 "	......	......	......

COLLECTED—*Con.*

Date.	Hour.	Depth in metres.	Air temperature t C.	Tide.	Wind.	Sky.	Depth of determinations in metres.	Water temperature t C.	Chlorine Cl. °/oo	Salinity S. °/oo	Density σ_t.	Colour of water.
1916.												
Sept. 25	10.19 a.m.	24 m.	13·40	High tide.	Quite heavy N.W. breeze.	Haze.	Surface.	14·05	16·14	29·17	21·71	Muddy.
" 25	10.19 "	24 "	13·40	"	"	"	10 m.	13·99	16·81	30·38	22·64	"
" 25	10.19 "	24 "	13·40	"	"	"	20 m.	13·72	16·95	30·63	22·90	"
Sept. 25	4.28 p.m.	22 "	14·71	Low tide.	Heavy N.W. breeze.		Surface.	14·45	16·39	29·61	21·97	"
" 25	4.28 "	22 "	14·71	"	"	"	10 m.	14·18	16·41	29·65	22·05	"
" 25	4.28 "	22 "	14·71	"	"	"	20 m.	14·00	16·72	30·21	22·52	"
Sept. 26	10.54 a.m.	30 "	10·28	High tide.	Heavy N.W. breeze.	Partly cloudy.	Surface.	11·62	17·69	31·96	24·35	Gre'nish.
" 26	10.54 "	30 "	10·28	"	"	"	10 m.	11·62	17·36	31·36	23·88	Gray
" 26	10.54 "	30 "	10·28	"	"	"	20 m.	11·18	17·77	32·10	24·52	"
" 26	10.54 "	30 "	10·28	"	"	"	25 m.	11·17	17·79	32·15	24·55	"
Sept. 7	9.12 "	..	....	....	South.	Foggy.	Surface.	10·10	No water sample.			
" 7	9.33 "	..	11·70	....	"	"	"	10·00	17·76	32·09	24·71	
" 7	9.56 "	..	11·40	....	"	"	"	10·40	17·73	32·03	24·60	
" 7	10.16 "	..	11·80	....	"	"	"	10·80	17·69	31·96	24·49	
" 7	10.39 "	..	11·60	....	"	"	"	11·10	17·69	31·97	24·43	
" 7	11.02 "	..	11·80	....	"	"	"	11·20	Sample of water lost.			
" 7	11.22 "	..	11·50	....	"	"	"	9·95	17·51	31·64	24·36	
" 7	11.44 "	..	11·70	....	"	"	"	10·45	17·34	31·34	24·04	
" 7	12.10 p.m.	..	12·30	....	"	"	"	10·20	17·70	31·99	24·59	

Date.	Hour.	Locality.	Temperature.
1916.			
September 1	11.30 a.m.	Head Harbour to Petit Passage, 23 miles	10·90
" 1	11.45 a.m.	" " 25[illegible] "	10·95
" 1	12.00 p.m.	" " 27[illegible] "	9·20
" 1	12.15 p.m.	" " 29[illegible] "	9·05
" 1	12.30 p.m.	" " 31[illegible] "	10·85
" 1	12.45 p.m.	" " 33[illegible] "	9·90
" 1	1.00 p.m.	" " 35[illegible] "	9·80
" 1	1.15 p.m.	" " 37[illegible] "	9·85
" 1	1.30 p.m.	" " 39 "	9·55
" 1	1.45 p.m.	" " 40[illegible] "	10·00
" 1	2.00 p.m.	" " 42[illegible] "	9·75
" 1	2.15 p.m.	" " 43[illegible] "	9·10
" 1	2.30 p.m.	" " 45[illegible] "	9·00
" 1	2.45 p.m.	" " 47⅛ "	9·20

WESTERN ARCHIPELAGO



XVI.

HYDROIDS OF EASTERN CANADA.

By C. McLEAN FRASER, Ph.D., Curator of the Pacific Biological Station, Departure Bay, B.C.

INTRODUCTION.

Since the early days of the Geological Survey explorations, lists of hydroids have appeared in connection with those of other invertebrata. As in these instances the hydroids that appeared accidentally in the general collection were examined in connection with this general material or sent away for examination, there were seldom many species in the list. Verrill identified many of the species and collected in the Bay of Fundy and the gulf of St. Lawrence and his reports, although somewhat scattered were the most valuable previous to 1901, when Whiteaves, in his "Catalogue of the Marine Invertebrata of Eastern Canada," gave a comprehensive list including all the species that had been reported to that time. Since 1901 two lists have been published; the one by Stafford, in his "Fauna of the Atlantic Coast," which appeared in "Contributions to Canadian Biology," 1912, and the other my own list of the "Hydroids of Nova Scotia" in 1913. Certain references have also been made to Eastern Canadian distribution in the second and third parts of Nutting's monograph, published in 1904 and 1915, respectively.

In the meantime, collecting has been continued in connection with the Atlantic station, now at St. Andrews, N.B. The material accumulated was sent to me by Dr. A. G. Huntsman, with the request that I make an examination of it. It was of much interest to find it a most comprehensive collection, as shown by the fact that from it 79 species have been determined, while Whiteaves' list included but 58, Stafford's 69, six of which have neither name nor description, and my Nova Scotia list 50.

In some instances there is some doubt as to the validity of certain species. Stimpson named some species without giving figure or adequate description and A. Agassiz did the same. Some of these difficulties were straightened out by contemporaries, but with others there is still some confusion. Taking all together, 112 species have been determined with reasonable assurance, although in two or three cases, mentioned in the text, there is still some possibility of synonymy. The six unnamed species of Stafford's are not included in this number. In listing the hydroids in this latest collection, it is as well to include all, to bring the whole list from the eastern coasts of Canada to date.

Some Newfoundland locations are given but these are all on the gulf of St. Lawrence side. No attempt has been made to include the species reported north of the strait of Belle Isle.

Of the 112 species, 16 are reported for the first time in this area, but only one of these, *Bimeria brevis,* is described as new to science. The others are: *Dicoryne conferta, Garveia grœnlandica, Eudendrium album, Eudendrium annulatum, Tubularia spectabilis, Campanularia gigantea, Clytia cylindrica, Clytia edwardsi, Obelia articulata, Opercularella pumila, Stegopoma plicatile, Hebella pocillum, Sertularia cornicina, Antennularia americana, Plumularia setaceoides.*

The purpose of the paper is to give a complete list of species of hydroids that have been reported from the waters along the eastern coasts of Canada, with the distribution of each in this area, to give a synonymy which will include that given with the original description and one or more others where good descriptions or figures appear and all the references in connection with points in this area and to give an account of any new or important point noted.

GEOGRAPHIC DISTRIBUTION.

For the consideration of the question of distribution, the waters of Eastern Canada can be conveniently divided into three regions: (1) The Bay of Fundy and its approaches, (2) the Gulf of St. Lawrence, (3) the east or southeast coast of Nova Scotia.

In the Bay of Fundy the waters around the island of Grand Manan have been much used as a collecting ground ever since Stimpson found a sufficient number of species to make it worth while to write up "The Marine Invertebrates of Grand Manan." Then, as now, it was recognized that on account of the exposed position and the difference in tides, the channels between the numerous small islands must be continually supplied with enough food for countless forms of great variety. The archipelago between Passamaquoddy bay and the Bay of Fundy proper provides a large area where the conditions are somewhat similar although the salinity becomes noticeably less in the inner waters. The whole area is suitable for hydroid growth. Even at the mouth of the St. Croix river there is a sufficient interchange on account of the high tides to permit of the existence of some species. Most of the collecting has been done in shallow water and near shore, hence although 87 species have been obtained, the probability is that many others exist in areas as yet untouched.

Apart from the Passamaquoddy archipelago, one other point must be mentioned and this at the other side of the Bay of Fundy. St. Mary bay, near Brier island, Nova Scotia, must be a very satisfactory locality for hydroids. All the material sent from there, apparently was obtained during one trip, July 29-30, 1913, and yet from this material alone 30 species of hydroids were obtained. When that many were picked up in indiscriminate collecting, the locality must offer fine opportunities for one looking especially for hydroids.

The Gulf of St. Lawrence has been touched at only a few points, Malpeque, Gaspé, Seven islands, Anticosti, Bay of Islands, Newfoundland, and some individual dredging trips. It is quite possible that in the gulf there is no single restricted area that offers such a variety of conditions as that at the entrance to Passamaquoddy bay, yet along the whole coast there is variety in plenty and in the vast area of the gulf itself there are great differences in depth and in the nature of the bottom. While the 65 species already obtained may be representative, they must only serve as a sample of what is to be found there.

What is true of the Gulf of St. Lawrence is equally true of the Nova Scotia coast. The near shore waters have been touched only in the vicinity of Canso at the extreme east and at Barrington passage at the extreme south. The coast waters intervening are studded with small islands among which are innumerable channels with suitable conditions for a good food supply, in which no collecting has ever been done. The small amount of deep water dredging done by the United States Fish Commission gives some idea of the richness of the fauna in deep water. Of the 65 species from this area, five were found on sargassum from the gulf stream. These were *Syncoryne mirabilis, Clytia noliformis, Obelia hyalina, Sertularia cornicina* and *Plumularia setaceoides,* but the first two have also been reported from inshore.

In making a comparison of the hydroids found in these three areas, it will be noticed that of the 27 gymnoblastic species 25 have been found in the Bay of Fundy, 11 in the Gulf of St. Lawrence, and 15 off the Nova Scotia coast. The gymnoblastic forms are always an uncertain quantity, particularly in general collecting. So many of them are so delicate that they are soon past recognition unless they are preserved when taken from the water. It is quite possible, therefore, that the Bay of Fundy predominance is due to better preservation of material. Of the 26 species of Campanularians, 21 were found in the Bay of Fundy, 17 from the Gulf of St. Lawrence and 17 from the Nova Scotia coast, almost exactly the same proportion as the whole number of species. Of the 7 species of the Campanulinidæ, 3 were found in the Bay

of Fundy, 5 in the Gulf of St. Lawrence, and 2 off the Nova Scotia coast. These are small forms and easily overlooked. Of the 9 species of the Halecidæ, 8 were from the Bay of Fundy, 7 from the Gulf of St. Lawrence, and 4 from the Nova Scotia coast. There is no apparent reason why the Nova Scotia coast should be lacking but there is a similar lack in the Gulf of St. Lawrence in the Lafœidæ and Hebellidæ as out of the 11 species recorded, there are 7 from the Bay of Fundy, 3 from the Gulf of St. Lawrence and 9 from the Nova Scotia coast. In the Sertularidæ the gulf of St. Lawrence leads, as out of the 24 species, 19 are from the Bay of Fundy, 21 from the Gulf of St. Lawrence, and 14 from the Nova Scotia coast. As usual in temperate regions, the Plumularidæ are poorly represented. Out of the 8 species reported, 4 are from the Bay of Fundy, 1 from the Gulf of St. Lawrence and 4 from the Nova Scotia coast, only one species being reported from more than one place. Taking the coast as a whole, the gymnoblastic species and the Campanularidæ are well represented while the Halecidæ and the Sertularidæ are proportionately low in numbers.

With the distribution here recorded additional evidence is obtained regarding the conclusion that, for a large number of species, the distribution takes place southward along the continental shores from a central circumpolar area. Of the 112 species, 65 have been reported from the Arctic regions, 72 from the west of Europe, and 57 from the west coast of North America. Furthermore, it indicates that along these coasts there is no very definite break in the continuity at any one point, although, of course, some of them extend farther southward than others. Of the 77 species that have been reported from the east coast of the United States as well, 62 of them or 80 per cent occur in the Arctic regions, Western Europe, or the west coast of North America, and 21 of them appear in the list of 51 species obtained at Beaufort, N.C., in 1911.

A table shows the distribution of each species in these regions and another shows the distribution of the Gymnoblastea and the main families of the Calyptoblastea.

DISTRIBUTION TABLE FOR SPECIES.

	Bay of Fundy.	Gulf of St. Lawrence.	Atlantic Coast of Nova Scotia.	East Coast of United States.	Arctic regions.	West Coast of Europe.	Pacific Coast of North America.
Cordylophora lacustris	x	x		x		x	
Clava leptostyla	x	x	x	x		x	x
Monobrachium parasitum		x			x		x
Syncoryne mirabilis	x	x	x	x	x		x
Dicoryne conferta	x					x	
flexuosa	x		x				
Bimeria brevis	x						
Garveia grœnlandica		x			x		x
Bougainvillia carolinensis	x	x	x	x			
Eudendrium album	x			x		x	
annulatum	x				x	x	
capillare	x		x	x	x	x	x
cingulatum	x						
dispar	x	x	x	x			
rameum	x		x		x	x	x
ramosum	x	x	x	x		x	x
tenue	x		x	x			
Hydractinia echinata	x	x	x	x	x	x	
Myriothela phrygia	x				x	x	
Acaulis primarius	x			x	x		
Corymorpha pendula	x	x	x	x			
Tubularia couthouyi	x			x			
crocea	x		x	x			x
indivisa	x		x		x	x	x
larynx	x	x	x	x	x	x	x
spectabilis	x			x			
tenella	x		x	x			
Campanularia amphora	x		x	x			
flexuosa	x	x	x	x	x	x	
gelatinosa		x		x	x	x	x
gigantea	x	x		x		x	
grœnlandica	x		x		x	x	x
hincksi			x	x	x	x	x
integra	x	x		x	x	x	x
magnifica			x				
neglecta	x	x	x	x		x	
speciosa		x			x		x
verticillata	x	x	x	x	x	x	x
volubilis	x	x	x	x	x	x	x
Clytia cylindrica	x			x			x
edwardsi	x			x			x
johnstoni	x	x	x	x	x	x	x
noliformis	x	x	x	x			x
Eucopella caliculata	x	x	x	x	x	x	x
Gonothyræa gracilis	x		x	x	x	x	x
loveni	x	x	x	x	x	x	
Obelia articulata	x			x			
commissuralis	x	x	x	x			x
dichotoma	x	x	x	x	x	x	x
flabellata	x	x		x	x	x	x
geniculata	x	x	x	x	x	x	x
hyalina			x	x		x	
longissima	x	x		x	x	x	x
Calycella syringa	x	x	x	x	x	x	x
Cuspidella costata		x		x		x	
grandis		x			x	x	x
Opercularella lacerata	x		x	x	x	x	x
pumila	x			x			
Stegopoma plicatile		x			x	x	x
Tetrapoma quadridentatum		x			x		
Halecium articulosum	x			x		x	x
beani	x	x	x	x	x	x	
curvicaule	x					x	x
gracile	x	x		x			
halecinum	x	x		x	x	x	x
minutum	x	x	x		x		
muricatum	x	x	x		x	x	x
sessile		x				x	
tenellum	x	x	x	x	x	x	x

DISTRIBUTION TABLE FOR SPECIES—*Concluded.*

—	Bay of Fundy.	Gulf of St. Lawrence.	Atlantic Coast of Nova Scotia.	East Coast of United States.	Arctic regions.	West Coast of Europe.	Pacific Coast of North America.
Hebella calcarata			x	x			
pocillum	x			x	x	x	x
Cryptolaria triserialis			x				
Filellum serpens	x		x	x	x	x	x
Grammaria abietina	x	x	x		x	x	x
gracilis	x						
Lafœa dumosa	x	x	x	x	x	x	x
fruticosa	x		x		x	x	x
gracillima	x	x	x	x	x	x	x
pygmæa			x			x	
symmetrica			x			x	
Abietinaria abietina	x	x	x	x	x	x	x
filicula	x	x		x	x	x	x
Diphasia fallax	x	x	x	x	x	x	
rosacea	x	x	x	x	x	x	
tamarisca	x		x		x	x	
Hydrallmania falcata	x	x	x	x	x	x	
Selaginopsis mirabilis		x	x	x	x	x	x
Sertularella conica			x	x			x
fusiformis		x				x	x
polyzonias	x	x	x	x	x	x	x
rugosa	x	x		x	x	x	x
tricuspidata	x	x	x	x	x	x	x
Sertularia cornicina			x	x			
pumila	x	x	x	x	x	x	x
Thuiaria argentea	x	x	x	x	x	x	x
cupressina	x	x	x	x	x	x	
fabricii	x	x		x	x	x	x
immersa	x	x			x		
latiuscula	x	x					
lonchitis	x	x	x	x	x	x	
robusta		x			x		x
similis	x	x					x
tenera	x	x			x	x	x
thuja	x	x		x	x	x	x
Aglaophenopsis cornuta			x		x		
Antennularia americana	x			x			
antennina	x			x	x	x	
Cladocarpus pourtalesi			x	x		x	
speciosus			x				
Plumularia setaceoides			x	x			
Schizotricha gracillima	x			x		x	
Thecocarpus myriophyllum	x	x		x		x	

SUMMARY OF DISTRIBUTION.

—	Total.	Bay of Fundy.	Gulf of St Lawrence.	Atlantic Coast of Nova Scotia.	East Coast of United States.	Arctic regions.	West Coast of Europe.	Pacific Coast of North America.
Gymnoblastea	27	25	11	15	17	11	12	10
Campanularidæ	26	21	17	17	23	16	18	18
Campanulinidæ	7	3	5	2	4	5	5	4
Halecidæ	9	8	7	4	5	6	7	4
Hebellidæ and Lafœidæ	11	7	3	9	5	6	8	6
Sertularidæ	24	19	21	14	17	19	18	15
Plumularidæ	8	4	1	4	6	2	4	

It is interesting to compare this list with the list of those that have been found in the Vancouver island region. Although this region is somewhat farther north than the Bay of Fundy or the greater part of the gulf of St. Lawrence, it is not subject to the same cold currents, hence the conditions are to some extent comparable.

In my 1914 paper, 136 species were listed and since then 4 more have been added to the list, making 140 in all. Of these 48 appear as well on the eastern Canadian list. On the west coast, of the families represented, the Sertularidæ is the most numerous, with 41 species, 29 per cent of the whole number, the Campanularidæ next with 34 or 24 per cent. The Gymnoblastea is represented by 25 species, 18 per cent, and the Halecidæ with 16 or 11 per cent. This is not the order on the east coast. The gymnoblastic species are more numerous than the species of any calyptoblastic family, there being 27 or 24 per cent of the whole number. The Campanularidæ with 26 or 23 per cent beats the Sertularidæ with 24 or 21 per cent and the Haleeidæ has only 9 representatives or 8 per cent. The Plumularidæ, a large family, is represented by only 8 species in each case, and as none of these are common there can scarcely be a circumpolar centre for this family. A table will show this comparison more readily:—

——	Total.	Gym.	Campanularidæ.	Campanulinidæ.	Haleeidæ.	Hebellidæ and Lafoeidæ.	Sertularidæ.	Plumularidæ.
Eastern Canada	112	27	26	7	9	11	24	8
Vancouver Island region......	140	25	34	8	16	8	41	8

SYSTEMATIC DISCUSSION.

With regard to nomenclature nothing need be said in connection with any of the families with the exception of the Sertularidæ. This family may well be considered on account of the treatment it has received in Levinsen's paper of 1913.[1] It is true that in this paper he introduces no opinions that were not found in his paper of 1893[2], but he goes into a much more elaborate defence of these opinions and hence the latter paper has received much more attention than the former.

In the classification of the Sertularidæ, as given in these papers, Levinsen casts all other characters aside and bases his entire taxonomic faith on the opercular apparatus as a basis for generic distinction. Naturally this throws the synonymy of the Sertularidæ, not by any means in a settled state, into greater confusion. Broch and Kramp have subscribed to his views but elsewhere they have found little favour when considered in their entirety although certain points have been accepted by a number of authors.

A lengthy discussion of the system, as expounded in the 1913 paper, will not be attempted here but a few general remarks on the soundness of the arguments deduced seems advisable.

The argument may be stated as follows: There are individual (zooidal) characters and colonial (zoarial) characters. In general the individual characters are better suited for taxonomy than colonial characters therefore all colonial characters should be excluded. Among the individual characters, some relate to the trophosome, some to the gonosome. Those relating to the trophosome are more suitable for taxonomy than those relating to the gonosome, therefore the gonosome characters should

[1] Systematic Studies in the Sertularidæ.

[2] Medusæ, Ctenophores and Hydroids of the West Coast of Greenland.

be excluded. Among the individual trophosome characters the nature of the opercular apparatus is a good character, therefore all other characters should be excluded and the opercular apparatus must form the one and only basis for the whole system of classification.

Let us examine the argument piece by piece. In the first place, without trying to settle the relative value of individual and colonial characters, are the colonial characters of such little value that they should be neglected entirely in classification? In connection with this, Levinsen drew an analogy in his earlier paper (p. 184) and was so well satisfied with it that he quoted it in his later paper (p. 255). It is this: "A zoological system based on that kind of characters may be compared to a botanical, in which the chief stress was laid on the inflorescences and not on the structure of the flowers. In both cases, the genus would contain a number of heterogeneous species. It can hardly be deemed doubtful that constant differences in the structure of the single individuals in question, of the hydrothecæ or hydranths, ought to be preferred as systematic characters, and that colonial characters ought only to be used when structural diversities were not to be found."

The analogy is somewhat unfortunate as in many cases the inflorescence is characteristic not only for the genus but even for the family. What more constant character would it be possible to get than the head of the Compositæ, the loose raceme of the Ranunculaceæ or the compound umbel of the Umbelliferæ? In the great majority of cases each species has a typically characteristic habitus and whatever in addition may be used as a basis for first diagnosis, as soon as the plant becomes familiar, it will be recognized by its inflorescence rather than by any single characteristic of the flower itself. So too in the case of the hydroids, each species has its own typical habitus by which it is recognized and if the genus has not so much the worse for the genus or the validity of it. The fact that the habitus of the young colony may be somewhat different to that of the colony at a later period and depends to a certain extent on environment, rather increases than decreases the value of this as a distinctive character when the life history is known. In any case even if the colonial characters, taken as a whole, are not of so much value as the individual characters, there is no reason that they should be discarded.

Turning to the next part of the argument, the characters of the gonosome are neglected because they are less important than the characters of the trophosome. Are the characters of the gonosome of so little account? Turning again to the floral analogy, how much of any system of classification would be left if all the references to the nature of the gynœcium and andrœcium and their relations to other parts of the flower were left out? In all other families of hydroids the characters of the gonosome are used extensively for taxonomy, why should they not be used in the Sertularidæ?

Finally, going back to the floral analogy once more, is it possible to find a single family of plants of any size that is divided into genera on the basis of a single character of the floral envelopes? In the hydroids as well, although one character in a family may be prominent, it is seldom that the paucity of characters is so marked as to make it necessary to rely on one character of the trophosome alone as the determining factor throughout.

Some of the points as they appear in Levinsen's paper may well be considered. After showing that the different species of *Selaginopsis* do not fit in in with the generic idea when based on the nature of the opercular apparatus, the following statement is made: "The fact that there is no constant relation between the structure of the zooids and the colonial form, or to express it in another way, that they are incommensurable values defined by different laws, must have the logical sequence, that one of them cannot be substituted for the other, and, therefore, a genus ought never to be instituted solely on the basis of a difference in the colonial form, when otherwise the zooids present distinct structural diversities" (p. 259). To state that the conclusion that "there is no constant relation between the structure of the zooids and the colonial form" is a

fact, upon such little basis, makes it necessary to materially discount any argument based on the statement. The resultant assertion depends for its value on the significance of the word "distinct." According to the remainder of the paper it might better have read "when otherwise the zooids present differences in the opercular apparatus" but with such an interpretation every other taxonomist will not necessarily agree. Some of them may even have the temerity still to believe that there may be some correlation between colonial and individual characters.

Levinsen entirely neglects the systematic value of the characters of the gonosome and hence in the genera in which he has introduced the most radical changes are to be found the widest diversity in these characters. In the genus *Sertularia* "the gonothecæ present a very different habitus, being either smooth, ringed or provided with two or more spines" (p. 298), and in the genus *Odontotheca* "the gonothecæ present a very variable habitus, being either smooth, ringed or provided with two spines" (p. 308). No system of classification based on colonial characters could present more "distinct structural diversities" than this.

With regard to the nature of the opercular apparatus almost anyone will admit that it is a good character, but even if it were the most suitable single character for diagnosis, it would not signify that the whole classification must depend on it, since there are other good characters. Levinsen says, "It seems reasonable to ascribe systematic significance also to the operculum, a structure that must be regarded as the complement of the protective cases, and, so to speak, as the end result of the same effort which led to the formation of the hydrothecæ and gonothecæ" (p. 288), and yet in this classification all of the hydrotheca with the exception of the opercular apparatus receives no consideration and the gonotheca is left out entirely. Farther on in the same paragraph he says the operculum" has in common with other structures of systematic significance, a rich development of characteristic modifications which give excellent generic characters," but in his classification he has eliminated the consideration of "other structures of systematic significance."

It seems a very satisfactory character in one respect as any cases of disagreement can be blamed on regeneration or injury but the very fact that regeneration is so very apt to take place and that the apparatus is so delicate as to be so susceptible to injury, makes its value for diagnosis of doubtful significance. After one has spent as much time and observation on the operculum as Levinsen did before writing this paper it might be possible to judge the nature of the operculum correctly from the appearance of the rest of the apparatus even when the operculum has been torn away but one with less experience will certainly have serious doubts at times when the operculum is not present and it is not always possible to have an unlimited supply of material to examine for hydrothecæ perfect in this respect. When Levinsen finds it necessary to disagree with the interpretation put upon the nature of the opercular apparatus by so many careful hydroid observers, e.g., with Nutting in the case of *Sertularia pumila*, it is evident that the adoption of a system based on such a character instead of bringing about a desirable degree of unanimity will tend to make the disagreement much more pronounced.

There can be little natural about a system of classification that makes it necessary to combine the genera *Abietinaria* and *Diphasia* into a single genus to make it fit in with the classification when the differences are so evident that they are immediately separated into the same two parts but called groups instead of genera for appearance, sake.

Levinsen objects to certain genera because there are intergrading forms but his classification leaves just as large a crop of these as is to be found in any other system. There will always be these intergrading forms but nothing is to be gained by crying down one system on this account when no improvement is made in a proposed substitute. When an attempt is made to fit in a system of classification of the Sertularidæ depending on the nature of the opercular apparatus with the general classifica-

tion of the hydroids in use, we have, to use Levinsen's words, "incommensurables defined by different laws, so that we must have the logical sequence, that one of them cannot be substituted for the other."

While, therefore, the care with which Levinsen did this work on the opercular apparatus is fully recognized and while the value to systematists of this exhaustive examination is in no way under-estimated, it is impossible to do otherwise than conclude as many others have done, that although the nature of the opercular apparatus is a good character and is of much value in classification, it cannot be used satisfactorily as the sole basis on which to divide the Sertularidæ into genera. The time may come when there will be more general agreement on the method of classifying this family but it will be at a time when all the main variable features of each species will be taken into consideration.

As this paper is on distribution rather than on taxonomy, it is not desirable to discuss in detail this or any other system of classification. By adhering to the nomenclature used throughout in previous papers for the Sertularidæ as for the other families, there will at least be no difficulty in following the references to the various species considered.

Sub-order *GYMNOBLASTEA.*

Family *CLAVIDÆ.*

Genus CORDYLOPHORA.

Cordylophora lacustris Allman.

Cordylophora lacustris Allman, Ann. and Mag. Nat. Hist., 1st ser. viii., 1844, p. 330.
Hincks, Br. Hydroid Zoophytes, 1868, p. 16.
Stafford, Fauna Atlantic Coast, 1912, p. 72.

Distribution.—St. Andrews, Gaspé, Seven islands (Stafford).

Although this is a fresh- or brackish-water form, since it has been reported it is well to include it in the list.

Genus CLAVA.

Clava leptostyla Agassiz.

Clava multicornis Stimpson, Marine Invert. Grand Manan, 1853, p. 16.
Clava leptostyla Agassiz, Cont. Nat. Hist. U.S., vol. iv, 1862, p. 218.
Hincks, British Hydroid Zoophytes, 1868, p. 6.
Nutting, Hyd. Woods Hole, 1901, p. 321.
Hargitt, Am. Nat. 1901, p. 305.
Whiteaves, Mar. Invert. East. Can., 1901, p. 18.
Stafford, Fauna Atlantic Coast, 1912, p. 72.
Fraser, Hyd. Nova Scotia, 1913, p. 159.

Distribution.—Salmon Bay (Packard); Long island point to Labrador (Verrill); St. Andrews, Canso, Seven islands (Stafford); Canso (Fraser); St. Andrews.

Family *LARIDÆ.*

Genus MONOBRACHIUM.

Monobrachium parasitum *Mereschkowsky.*

Monobrachium parasitum Mereschkowsky, Hyd. from White Sea, 1877, p. 226.
Levinsen, Medusæ, Ctenophorer, etc., 1893, p. 151.
parasiticum Bonnevie, Norske Nordhavs-Ex., 1899, p. 151.
parasitum Stafford, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Gaspé (Stafford).

Family *DICORYNIDÆ.*

Genus DICORYNE.

DICORYNE CONFERTA (Alder).

Eudendrium confertum ALDER, Trans. Tynes. Nat. F.C., iii, 1857, p. 103.

Dicoryne conferta HINCKS, Br. Hyd. Zooph., 1868, p. 105.
ALLMAN, Gymnoblastic Hyd., 1871, p. 293.

Distribution.—Off Minister's island.

DICORYNE FLEXUOSA G. O. Sars.

Dicoryne flexuosa SARS, Bidrag til Kundskaben om Norges Hydroider, 1873, p. 96.
VERRILL, Am. Jour. Sci. and Art, 3rd. ser., vol. xvi, 1878, p. 375.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 19.
STAFFORD, Fauna Atlantic Coast, 1912, p. 72.

Distribution.—Off Nova Scotia, 50 to 125 fathoms (Verrill); St. Andrews (Stafford).

Family *SYNCORYNIDÆ.*

Genus SYNCORYNE.

SYNCORYNE MIRABILIS (Agassiz).

Coryne mirabilis AGASSIZ, Cont. Nat. Hist. U.S., vol. iv, 1862, p. 185.

Syncoryne mirabilis NUTTING, Hydroids of Woods Hole, 1901, p. 328.
HARGITT, Am. Nat., 1901, p. 328.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 19.

Dicoryne mirabilis STAFFORD, Fauna Atlantic Coast, 1912, p. 72.

Distribution.—Belles Amours, strait of Belle Isle (Packard); bay of Fundy (Verrill); Seven islands (Stafford); Katy cove; on sargassum in the Gulf Stream east of Nova Scotia.

Family *BIMERIDÆ.*

Genus BIMERIA.

BIMERIA BREVIS new species.

(Fig. 2).

Trophosome.—Stem simple, growing from a creeping hydrorhiza; in many cases it forms a long pedicel for a single hydranth but in others it may give off several hydranths, each on a pedicel of its own, and occasionally these pedicels may be branched. The greatest length observed was 8 mm. In the branched specimens, the branches do not come off at regular intervals, either vertically or laterally; each makes quite an acute angle with the stem. The perisarc is quite thick and wrinkled but no definite annuli are formed; the portion around the body of the hydranth is closely wrinkled or creased; hydranth small with 11-12 tentacles.

Gonosome.—Absent.

Distribution.—On *Tubularia crocea* from Katy cove.

The habitus of this species is much similar to that of *Bimeria humilis* Allman[3], but the stem is relatively much stouter, the hydranths are much smaller and the perisarc is much more wrinkled. In any case one should scarcely expect to find a species that was obtained in the warm, shallow water of the Tortugas to occur in the cold water of the bay of Fundy. It bears less resemblance to *Bimeria vestita* Wright as it is a shorter but coarser species.

[3] Allman, G. J. Gulf Stream Hydroids, 1877, p. 9.

Genus GARVEIA.

GARVEIA GRŒNLANDICA Levinsen.

Garveia grœnlandica LEVINSEN, Meduser, Ctenophorer, etc., 1893, p. 155.
FRASER, Vancouver island hydroids, 1914, p. 117.

Distribution.—Bay of islands, Newfoundland, 50 to 60 fathoms.

Family *BOUGAINVILLIDÆ.*

Genus BOUGAINVILLIA.

BOUGAINVILLIA CAROLINENSIS (McCrady).

Hippocrene carolinensis MCCRADY, Gymno. of Charleston Har., 1857, p. 62.

Margelis carolinensis AGASSIZ, Cont. Nat. Hist. U.S., vol. iv, 1862, p. 344.
A. AGASSIZ, N. A. Acalephæ, 1865, p. 156.

Bougainvillia carolinensis NUTTING, Hyd. Woods Hole, 1901, p. 330.
STAFFORD, Fauna Atlantic Coast, 1912, p. 72.
FRASER, New England Hydroids, 1912, p. 41.
FRASER, Hyd. of Nova Scotia, 1913, p. 159.

Distribution.—St. Andrews, Seven islands (Stafford); Canso (Fraser); Katy cove, Joe's point.

The specimens of this species collected at Katy cove were small as compared with those described from Woods Hole. None of them were more than an inch in length but the medusa buds were well developed.

Family *EUDENDRIDÆ.*

Genus EUDENDRIUM.

EUDENDRIUM ALBUM Nutting.

Eudendrium album NUTTING, Ann. and Mag. Nat. Hist., 1898, p. 362.
Hyd. Woods Hole, 1901, p. 334.
HARGITT, Biol. Bull., 1908, p. 97.
FRASER, Hyd. of Beaufort, 1912, p. 348.

Distribution.—Off Deer point, Campobello island, and at many points between this and Dochet island up the St. Croix river, off Brier island, Nova Scotia, 33 to 39 fathoms.

EUDENDRIUM ANNULATUM Norman.

Eudendrium annulatum NORMAN, Ann. and Mag. Nat. Hist., 1864, p. 83.
HINCKS, Br. Hyd. Zooph., 1868, p. 83.
JÄDERHOLM, Northern and Arctic Invert., 1909, p. 51.

Distribution.—Brier island, 25 fathoms.

EUDENDRIUM CAPILLARE Alder.

Eudendrium capillare ALDER, Cat. Zooph. Northumberland and Durham, 1857, p. 15.
HINCKS, Br. Hyd. Zooph., 1868, p. 84.
ALLMAN, Gymno. Hyd. 1871, p. 335.
NUTTING, Woods Hole Hyd., 1901, p. 334.
WHITEAVES, Marine Invert. East Can., 1901, p. 20.
FRASER, Hyd. of Beaufort, 1912, p. 348.
STAFFORD, Fauna Atlantic Coast, 1912, p. 72.

Distribution.—Le Have bank, 45 fathoms (Smith and Harger); St. Andrews (Stafford); Weir stakes at St. Andrew's island; off L'Etang head, 12 fathoms.

EUDENDRIUM CINGULATUM Stimpson.

Eudendrium cingulatum STIMPSON, Marine invert. Grand Manan, 1854, p. 9.
WHITEAVES, Marine Invert. East. Can., 1901, p. 20.

Distribution.—Off Duck Island, Grand Manan (Stimpson).

Stimpson's description of this species is very meagre but it seems to agree very well with that for *E. annulatum* Norman and very probably it is the same species. If it is the name *E. annulatum* should be retained as it has priority. A. Agassiz considered it to be the same as *Bougainvillia supercilaris* Agassiz (See N. A. Acalephæ, 1865, p. 153).

EUDENDRIUM DISPAR Agassiz.

Eudendrium dispar AGASSIZ, Cont. Nat. Hist. U.S., vol. iv, 1862, p. 285.
NUTTING, Hyd. Woods Hole, 1901, p. 332.
HARGITT, Am. Nat., 1901, p. 309.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 20.
STAFFORD, Fauna Atlantic Coast, 1912, p. 72.
FRASER, Hyd. Nova Scotia, 1913, p. 160.

Distribution.—Vineyard sound to bay of Fundy (Verrill); St. Andrews, Seven islands (Stafford); Barrington passage (Fraser); Off Head Harbour Island. Off McMaster island, weir stakes, St. Andrews island, Joe's point, reef off St. Andrews, 10 fathoms.

EUDENDRIUM RAMEUM (Pallas).

Tubularia ramea PALLAS, Elench. Zooph., 1766, p. 83.

Eudendrium rameum HINCKS, Br. Hyd. Zooph., 1868, p. 80.
WHITEAVES, Mar. Invert. East Can., 1901, p. 19.
JÄDERHOLM, Northern and Arctic Invert., 1909, p. 50.

Distribution.—30 miles southeast of Halifax in 100 fathoms (Verrill); near Two islands, Grand Manan, 5-10 fathoms, off L'Etang head, off Joe's point, Weir stakes, St. Andrews island.

EUDENDRIUM RAMOSUM (Linnæus).

Tubularia ramosa LINNAEUS, Syst. Nat., 1758, p. 804.

Eudendrium ramosum HINCKS, Br. Hyd. Zooph., 1868, p. 82.
NUTTING, Hyd. Woods Hole, 1901, p. 332.
HARGITT, Am. Nat, 1901, p. 309.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 19.
STAFFORD, Fauna Atlantic Coast, 1912, p. 72.
FRASER, Hyd. Nova Scotia, 1913, p. 160.

Distribution.—Bay of Fundy, 8 to 100 fathoms (Verrill); 8 miles southeast of Bonaventure island (Whiteaves); Métis and Murray bay (Dawson); St. Andrews, Gaspé, Seven islands (Stafford); Chedabucto bay, 45 fathoms (Fraser); many localities from Two islands to St. Andrews point, Brier island.

EUDENDRIUM TENUE A. Agassiz.

Eudendrium tenue A. AGASSIZ, N.A. Acalephæ, 1865, p. 160.
NUTTING, Hyd. Woods Hole, 1901, p. 333.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 20.
STAFFORD, Fauna Atlantic Coast, 1912, p. 72.
FRASER, Hyd. Nova Scotia, 1913, p. 160.

Distribution.—Buzzards bay to Bay of Fundy, low water to 15 fathoms (Verrill); St. Andrews (Stafford); Canso (Fraser); many points from St. Andrews to L'Etang head, off Brier island.

Family *HYDRACTINIDÆ.*

Genus HYDRACTINIA.

Hydractinia echinata (Fleming).

Alcyonium echinatum Fleming, Br. Animals, 1828, p. 517.
Hydractinia echinata Hincks, Br. Hyd. Zooph., 1868, p. 23.
polyclina Agassiz, Cont. Nat. Hist., U.S., 1862, p. 227.
Nutting, Hyd. Woods Hole, 1901, p. 335.
echinata Whiteaves, Mar. Invert. East. Can., 1901, p. 21.
Hargitt, Am. Nat., 1901, p. 310.
Stafford, Fauna Atlantic Coast, 1912, p. 73.
Fraser, Hyd. Beaufort, 1912, p. 352.
Fraser, Hyd. Nova Scotia, 1913, p. 161.

Distribution.—New Jersey to Labrador (Verrill); St. Andrews, Malpeque, Gaspé, Seven islands (Stafford); Grand Manan (A. Agassiz); Canso (Fraser); High Duck island.

Family *MYRIOTHELIDÆ.*

Genus MYRIOTHELA.

Myriothela phrygia (Fabricius).

Lucernaria phrygia Fabricius, Fauna Grœnlandica, 1780, p. 343.
Myriothela phrygia Hincks, Br. Hyd. Zooph., 1868, p. 77.
Whiteaves, Mar. Invert. East. Can., 1901, p. 20.

Distribution.—"Grand Manan, bay of Fundy, W. Stimpson" (L. Agassiz).

Family *PENNARIDÆ.*

Genus ACAULIS.

Acaulis primarius Stimpson.

Acaulis primarius Stimpson, Mar. Invert. Grand Manan, 1854, p. 10.
Whiteaves, Mar. Invert. East. Can., 1901, p. 21.

Distribution.—Grand Manan, 5 to 15 fathoms (Stimpson).

Family *CORYMORPHIDÆ.*

Genus CORYMORPHA.

Corymorpha pendula Agassiz.

Corymorpha nutans Stimpson, Mar. Invert. Grand Manan, 1854, p. 9.
pendula Agassiz, Cont. Nat. Hist. U. S., vol. iv, 1862, p. 227.
Nutting, Hyd. Woods Hole, 1901, p. 337.
Hargitt, Am. Nat., 1901, p. 312.
Monocaulis glacialis Whiteaves, Mar. Invert. East. Can., 1901, p. 21.
Stafford, Fauna Atlantic Coast, 1912, p. 73.
Corymorpha pendula Fraser, Hyd. Nova Scotia, 1913, p. 161.

Distribution.—West Quoddy head, Welsh pool, Low Duck island, 4 to 15 fathoms, (Stimpson); bay of Fundy, Murray bay (Verrill); Rodger's island, Oak bay, Charlotte county (Ganong); St. Andrews (Stafford); Chedabucto bay (Fraser); St. Andrews, Wolves island, Harbour island, 25 fathoms.

Family *TUBULARIDÆ*.

Genus TUBULARIA.

TUBULARIA COUTHOUYI Agassiz.

Tubularia couthouyi AGASSIZ, Cont. Nat. Hist. U. S., 1862, p. 266.
A. AGASSIZ, N. A. Acalephæ, 1865, p. 196.
NUTTING, Hyd. Woods Hole, 1901, p. 338.

Distribution.—Grand Manan (A. Agassiz).

TUBULARIA CROCEA (Agassiz).

Parypha crocea AGASSIZ, Cont. Nat. Hist., U. S., 1862, p. 249.

Tubularia crocea NUTTING, Hyd. Woods Hole, 1901, p. 340.
HARGITT, Am. Nat., 1901, p. 315.
FRASER, New England Hydroids, 1912, p. 42.
FRASER, Hyd. Nova Scotia, 1913, p. 162.

Distribution.—Canso (Fraser); Katy cove, St. Andrews, L'Etang head, Weir stakes, St. Andrews island.

TUBULARIA INDIVISA Linnæus.

Tubularia indivisa LINNÆUS, Syst. Nat. 1767, p. 1301.
STIMPSON, Mar. Invert. Grand Manan, 1853, p. 9.
HINCKS, Br. Hyd. Zooph., 1868, p. 115.
WHITEAVES, Mar. Inv. East. Can., 1901, p. 21.
STAFFORD, Fauna Atlantic Coast, 1912, p. 72.

Distribution.—Grand Manan (Stimpson); Sable island (Dawson); Le Have bank (Smith and Harger); St. Andrews (Stafford); St. Andrews, Joe's point, off Deer island, off L'Etang head.

TUBULARIA LARYNX Ellis and Solander.

Tubularia larynx ELLIS AND SOLANDER, Nat. Hist. of Zooph., 1786, p. 31.
STIMPSON, Mar. Invert. Grand Manan, 1854, p. 9.
HINCKS, Br. Hyd. Zooph., 1868, p. 118.
NUTTING, Hyd. Woods Hole, 1901, p. 338.
WHITEAVES, Mar. Invert. East Can., 1901, p. 20.

Thamnocnidia larynx STAFFORD, Fauna Atlantic Coast, 1912, p. 72.

Tubularia larynx FRASER, Hyd. Nova Scotia, 1913, p. 162.

Distribution.—Grand Manan (Stimpson); Orphan bank (Whiteaves); Gaspé bay (Dawson); St. Andrews, Malpeque, Gaspé (Stafford); Barrington passage (Fraser); York harbour, Newfoundland.

TUBULARIA SPECTABILIS (Agassiz).

Thamnocnidia spectabilis AGASSIZ, Cont. Nat. Hist. U. S., vol. iv, 1862, p. 271.

Tubularia spectabilis NUTTING, Hyd. Woods Hole, 1901, p 339.

Distribution.—Minister's bay, east point of Bliss island.

TUBULARIA TENELLA (Agassiz).

Thamnocnidia tenella AGASSIZ, Cont. Nat. Hist. U.S., vol. iv, 1862, p. 275.

Tubularia tenella NUTTING, Hyd. Woods Hole, 1901, p. 339.
HARGITT, Am. Nat., 1901, p. 314.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 20.
FRASER, Hyd. Nova Scotia, 1913, p. 162.

Distribution.—Bay of Fundy, low water to 40 fathoms (Verrill); St. Andrews, Canso, Gaspé, Seven islands (Stafford); Canso (Fraser); Niger reef, weir stakes, St. Andrews island.

Sub-order *CALYPTOBLASTEA.*

Family *CAMPANULARIDÆ.*

Genus CAMPANULARIA.

CAMPANULARIA AMPHORA (Agassiz).

Laomedea amphora AGASSIZ, Cont. Nat. Hist. U. S., vol. iv, 1862, p. 311.
Campanularia amphora NUTTING, Hyd. Woods Hole, 1901, p. 347.
HARGITT. Am. Nat., 1901, p. 384.
FRASER, Hyd. Nova Scotia, 1913, p. 163.
NUTTING, Am. Hyd., pt. iii, 1915, p. 50.

Distribution.—Grand Manan (A. Agassiz); Canso (Fraser); Grand Manan (Nutting).

CAMPANULARIA FLEXUOSA (Hincks).

Laomedea flexuosa HINCKS, Ann. and Mag. Nat. Hist., 1861, p. 260.
Campanularia flexuosa HINCKS, Br. Hyd. Zooph., 1868, p. 168.
NUTTING, Hyd. Woods Hole, 1901, p. 348.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 22.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 163.
NUTTING, Am. Hyd., iii, 1915, p. 45.

Distribution.—Bay of Fundy to gulf of St. Lawrence (Verrill); St. Andrews, Canso, Gaspé, Seven islands (Stafford); Canso (Fraser); Niger reef, weir stakes, St. Andrews island.

CAMPANULARIA GELATINOSA (Pallas).

Sertularia gelatinosa PALLAS, Elench. Zooph., 1766, p. 116.
Laomedea gelatinosa STIMPSON, Mar. Invert. Grand Manan, 1854, p. 8.
Obelia gelatinosa HINCKS, Br. Hyd. Zooph., 1868, p. 151.
NUTTING, Hyd. Woods Hole, 1901, p. 351.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 23.
Campanularia gelatinosa FRASER, Hyd. of Vancouver island, 1914, p. 135.
Obelaria gelatinosa NUTTING, Am. Hyd., iii, 1915, p. 88.

Distribution.—Métis (Dawson); Near Caribou island (Packard).

This species is discussed at length in the Vancouver island paper.

CAMPANULARIA GIGANTEA Hincks.

Campanularia gigantea HINCKS, Ann. and Mag., Nat. Hist., 1866, p. 297.
Br. Hyd. Zooph., 1868, p. 174.
NUTTING, Am. Hyd., iii, 1915, p. 44.

Distribution.—Bay of Islands, Newfoundland, 50 to 60 fathoms, off Long island, 15 to 35 fathoms, St. Croix river, 5 to 10 fathoms.

CAMPANULARIA GRŒNLANDICA Levinsen.

Campanularia grœnlandica LEVINSEN, Medusæ, Ctenophorer, etc., 1893, p. 26.
FRASER, Hyd. Nova Scotia, 1913, p. 163.
FRASER, Hyd. of Vancouver island region, 1914, p. 136.
NUTTING, Am. Hyd., iii, 1915, p. 38.

Distribution.—Canso banks, 50 fathoms (Fraser); Quoddy river, east of Spruce island, 17 fathoms, between White and Spruce islands, off Head Harbour island, 25 fathoms, off Deer point, Campobello island, off Brier island, 22 fathoms.

CAMPANULARIA HINCKSI Alder.

Campanularia hincksi ALDER, Trans. Tynes. F. C., iii, 1857, p. 162.
HINCKS, Br. Hyd. Zooph., 1868, p. 162.
NUTTING, Hyd. Woods Hole, 1901, p. 345.
WHITEAVES, Mar. Invert. East. Can., 1901 p. 22.
NUTTING, Am. Hyd., iii, 1915, p. 37.

Distribution.—Le Have bank, 45 fathoms (Smith and Harger).

CAMPANULARIA INTEGRA MacGillivray.

Campanularia integra MACGILLIVRAY, Ann. and Mag. Nat. Hist., 1842, p. 465.
HINCKS, Br. Hyd. Zooph., 1868, p. 163.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
NUTTING, Am. Hyd., iii, 1915, p. 33.

Distribution.—Seven islands (Stafford); Spruce island, Brier island, 33 to 39 fathoms.

CAMPANULARIA MAGNIFICA, Fraser.

Campanularia magnifica FRASER, Hyd. Nova Scotia, 1913, p. 164.
NUTTING, Am. Hyd., iii, 1915, p. 47.

Distribution.—Canso banks, 50 fathoms (Fraser); Off Newfoundland (Nutting).

CAMPANULARIA NEGLECTA (Alder).

Laomedea neglecta ALDER, Trans. Tynes. F. C., iii, 1857, p. 33.
Campanularia neglecta HINCKS, Br. Hyd. Zooph., 1868, p. 171.
NUTTING, Hyd. Woods Hole, 1901, p. 346.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 165.
NUTTING, Am. Hyd., iii, 1915, p. 46.

Distribution.—St. Andrews, Seven islands (Stafford); Canso (Fraser); throughout the area from Grand Manan to the St. Croix river, off Brier island.

CAMPANULARIA SPECIOSA Clark.

Campanularia speciosa CLARK, Alaskan Hydroids, 1876, p. 171.
LEVINSEN, Medusæ, etc., 1893, p. 167.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. V. I. region 1914, p. 139.
NUTTING, Am. Hyd., iii, 1915, p. 48.

Distribution.—Gaspé, Seven islands (Stafford).

The hydroids reported by Stafford as belonging to this species, in all probability, belong to the species *C. magnifica*. In the Vancouver island paper attention has been called to the fact that similar mistakes have been made elsewhere owing to similarity of the trophosome. The gonangia in the two species bear no resemblance to each other.

CAMPANULARIA VERTICILLATA (Linnæus).

Sertularia verticillata LINNÆUS, Syst. Nat., 1758, p. 811.
Campanularia verticillata HINCKS, Br. Hyd. Zooph., 1868, p. 167.
NUTTING, Hyd. Woods Hole, 1901, p. 347.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 22.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 165.
NUTTING, Am. Hyd. iii, 1915, p. 29.

Distribution.—Le Have banks, 45 fathoms (Smith and Harger); gulf of St. Lawrence (Packard); gulf of St. Lawrence, 20 to 50 fathoms (Whiteaves); St. Andrews, Gaspé, Seven islands (Stafford); Chedabucto bay, 50 fathoms (Fraser); Nova Scotia (Nutting); at several points in the area between Sand Reef light, L'Etang head and the north end of Campobello island.

CAMPANULARIA VOLUBILIS (Linnæus).

Sertularia volubilis LINNÆUS, Syst. Nat., 1767, p. 1311.
Campanularia volubilis HINCKS, Br. Hyd. Zooph., 1868, p. 160.
NUTTING, Hyd. Woods Hole, 1901, p. 345.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 22.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73
FRASER, Hyd. Nova Scotia, 1913, p. 165.
NUTTING, Am. Hyd., iii, 1915, p. 31.

Distribution.—Bay of Fundy, low water to 60 fathoms (Verrill); gulf of St. Lawrence, off Cap des Rosiers lighthouse in 7 fathoms (Whiteaves); St. Andrews, Gaspé, Seven islands (Stafford); Barrington passage, 5 fathoms, Canso banks, 50 fathoms (Fraser); at various points from the south end of Grand Manan to the head of Passamaquoddy bay, Brier island, 33 to 39 fathoms.

Genus CLYTIA.

CLYTIA CYLINDRICA Agassiz.

Clytia cylindrica AGASSIZ, Cont. Nat. Hist. U.S., iv, 1862, p. 306.
Platypyxis cylindrica A. AGASSIZ, N. A. Acelephæ, 1865, p. 80.
Clytia cylindrica FRASER, Hyd. Beaufort, 1912, p. 358.
FRASER, Grampus Hyd., 1915, p. 308.
NUTTING, Am. Hyd., iii, 1915, p. 58.

Distribution.—Chamcook har., 5 fathoms, off Bliss island.

CLYTIA EDWARDSI (Nutting).

Campanularia edwardsi NUTTING, Hyd. Woods Hole, 1901, p. 346.
Clytia edwardsi FRASER, West Coast Hyd., 1911, p. 34.
FRASER, New England Hyd., 1912, p. 44.
FRASER, Hyd. V. I. region, 1914, p. 143.
NUTTING, Am. Hyd., iii, 1915, p. 60.

Distribution.—St. Andrews Pt.

CLYTIA JOHNSTONI (Alder).

(Fig. 3).

Campanularia johnstoni ALDER, Ann. and Mag. Nat. Hist., 1856, p. 359.
Clytia johnstoni HINCKS, Br. Hyd. Zooph., 1868, p. 143.
Clytia bicophora AGASSIZ, Cont. Nat. Hist. U.S., iv, 1862, p. 304.
NUTTING, Hyd. Woods Hole, 1901, p. 343.
Clytia grayi NUTTING, Hyd. Woods Hole, 1901, p. 344.
Clytia bicophora HARGITT, Am. Nat. 1901, p. 381.
Clytia johnstoni WHITEAVES, Mar. Invert., East. Can., 1901, p. 24.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1915, p. 165.
NUTTING, Am. Hyd., iii, 1915, p. 54.
Clytia bicophora NUTTING, Am. Hyd., iii, 1915, p. 56.

Distribution.—Bay of Fundy, low water to 40 fathoms (Verrill); Le Have bank, 45 fathoms (Smith and Harger); Orphan bank (Whiteaves); St. Andrews (Stafford); Barrington passage, shallow water, Canso, low water (Fraser); Grand Manan (A. Agassiz); at various points from the south end of Grand Manan to the head of Passamaqoddy bay, off Brier island, 22 fathoms.

Since Agassiz described specimens from the New England coast and the Bay of Fundy as belonging to a new species *Clytia bicophora*, few authers have considered the species distinct from *Clytia johnstoni*. Nutting, in his Woods Hole paper, and later in his monograph, treats it so, but in his later paper he has included his earlier species, *Clytia grayi*, with *Clytia johnstoni*. He states that *Clytia bicophora* is a much more delicate and smaller species, the hydrothecæ of *C. johnstoni* being on the average twice as long and wide as those of *C. bicophora*," and later, "The diagnostic marks of *Clytia bicophora* are the comparatively small size of the hydrothecæ, the presence of a simple instead of a complex diaphragm, and the tenuity of the hydrothecal walls." He speaks of the diaphragm of *C. johnston* as being "strong, thicker than usual, and the basal chamber well shown." The hydrotheca of *C. johnstoni* is said to have 16 teeth, that of *C. bicophora*, 12 to 14.

In the material under consideration there were specimens of this species, or of these species, from 18 localities, ranging from the southern end of Grand Manan island, through Passamaquoddy bay and up the St. Croix river, the very region from which Agassiz obtained some of his specimens. There were also some from St. Mary bay on the Nova Scotia side of the Bay of Fundy. For comparison I have specimens from Canso, N.S., and Woods Hole, Mass., together with specimens of *Clytia johnstoni* from the coast of Devon, England, obtained from the British museum.

First considering the size of the hydrothecæ, Nutting gives no measurements, the figures are not all drawn to the same scale of magnification and the scale is not given in any instance, hence it is impossible to be sure what size he considers suitable for each species. It is possible to find in one locality a variation as great as he gives as the distinction and sometimes not far from that much variation in the one colony. The average size of the English specimens is much the same as that of the Canso and Woods Hole specimens and scarcely any of those found in the bay of Fundy were smaller than these, the majority being larger and some of them being much larger. Those from St. Mary bay were larger and most of those from Passamaquoddy bay and vicinity are also; those well in from the direct waters of the bay of Fundy are, in general, larger than those more nearly out in the open. Thus, those from the vicinity of Deer island and at the mouth of the St. Croix river are larger on the average than those obtained from Grand Manan, the Wolves and Bliss island.

Some measurements will show this: The length of the hydrothecæ in the Devon, Canso, and Woods Hole specimens, varies from 0·5 to 0·65mm., St. Mary bay, 0·55 to 0·65, Grand Manan, 0·45 to 0·8, Bliss island, 0·5 to 0·75, Deer island, 0·6 to 1·0, mouth of the St. Croix river, 0·75 to 1·05. The length varies from 1·5 to 2 times the breadth. The largest specimens answer well to the type on which Nutting based the species, *C. grayi*. It is scarcely probable that Nutting described *C. bicophora* from specimens with hydrothecæ half the length of the smallest of these. It is more likely that there is a variation in size in the British specimens as there is in the bay of Fundy specimens and possibly Nutting has examined some of the larger ones while I have some of the smaller ones.

With regard to the thickness of the diaphragm, it is quite natural that the larger specimens have thicker diaphragms than the smaller but I find that when the smaller ones are examined under higher magnification, so that they appear equal in size to the larger, there is no constant difference in the appearance of the diaphragm. This is borne out by Nutting's figures. In fig. 3, pl. XII, where the drawing of the hydrotheca of *C. bicophora* is shown as large as that of *C. johnstoni* in the preceding plate, the diaphragm is shown even more plainly than in the drawing of *C. johnstoni*. The same is true in the case of the basal chamber.

The tenuity of the hydrothecal walls may vary much in the same species and the collapsible appearance is often due to the length of time the hydroids are in stale water before they are examined or before they are preserved.

Finally as to the number of teeth in the margin of the hydrothecæ, the number may vary from 12 to 16 in the hydrothecæ of the same colony and they appear to be just as liable to be numerous in the small hydrothecæ as in the large ones.

While the chasm is a great one between the small specimens and the very large ones, when only those are seen, it becomes entirely bridged when all graduations are brought into view also. The conclusion that all specimens recorded as *C. bicophora*, *C. grayi* and *C. johnstoni* should be all included in the one species *C. johnstoni* (Alder) to me seems unavoidable.

Clytia noliformis (McCrady).

Campanularia noliformis McCrady, Gymno. Charleston har., 1857, p. 92.

Clytia noliformis Nutting, Hyd. Woods Hole, 1901, p. 343.
Fraser, Hyd. Beaufort, 1912, p. 359.
Stafford, Fauna Atlantic coast, 1912, p. 73.
Nutting, Am. Hyd., iii, 1915, p. 57.

Distribution.—Canso, Gaspé, Seven islands (Stafford); Briar island, 33 to 39 fathoms, on sargassum in Gulf Stream, east of Nova Scotia.

Genus EUCOPELLA.

Eucopella caliculata (Hincks).

Campanularia caliculata Hincks, Ann. and Mag. Nat. Hist., 1853, p. 178.

Clytia (*Orthopyxis*) *poterium* Agassiz, Cont. Nat. Hist. U. S., 1862, p. 297.

Orthopyxis poterium A. Agassiz, N. A. Acalephæ, 1865, p. 223.

Orthopyxis caliculata Verrill, Mar. Invert. Vineyard sound, 1873, p. 408.

Campanularia poterium Nutting, Hyd. Woods Hole, 1901, p. 344.

Campanularia caliculata Hargitt, Am. Nat., 1901, p. 383.
Whiteaves, Mar. Invert. Eastern Canada, 1901, p. 23.
Stafford, Fauna Atlantic coast, 1912, p. 73.

Eucopella caliculata Fraser, Hyd. Nova Scotia, 1913, p. 166.
Fraser, Hyd. V. I. region, 1914, p. 147.

Orthopyxis caliculata Bale, Proc. Roy. Soc. Vict., 1914, p. 72.
Nutting, Am. Hyd., iii, 1915, p. 64.

Distribution.—Bay of Fundy, low water to 30 fathoms, gulf of St. Lawrence at the Mingan islands, 6 fathoms (Verrill); Henley harbour, strait of Belle Isle, 20 to 30 fathoms (Packard); Seven islands (Stafford); Canso, 20 fathoms (Fraser); Sea Coal bay, N.S. (A. Agassiz).

In my previous papers where this species was recorded the name *Eucopella caliculata* has been used but now Bale and Nutting intimate that *Eucopella* must be discarded for *Orthopyxis*. It seems to be putting a big stretch on the law of priority when it is made to cover a name that was first applied to a subgenus and later a genus but admittedly never defined. It is all very well to speak of the "elaborate description" given by Agassiz for *Clytia* (*Orthopyxis*) *poterium*, but it was not sufficiently elaborate to give recognition to the fact that the species had already been described. In any case the description was not complete enough to convince Hincks of the necessity for the new genus for, while recognizing the identity of *Clytia poterium* with his own *Campanularia caliculata* in his 1868 work, he retains the name *Campanularia*.

Little stress can be laid on the fact that A. Agassiz used the name *Orthopyxis* in 1865 as there he simply refers to his father's collections without farther remarks.

A stronger argument for retaining *Orthopyxis* appears in the fact that Verrill used *Orthopyxis caliculata* in all the references to the species in his paper in 1873, giving a description of the species but not of the genus on page 408, but as he returns to *Campanularia caliculata* in 1874 and again in 1879, the argument loses its strength. Nutting has evidently overlooked these references of Verrill's for he says: "I cannot find any author has used the name *Orthopyxis* since 1865."

The name *Eucopella* has a different status for when von Lendenfeld introduced it in 1885 he defined the genus and other definitions given since then do not conflict with his definition. Since the genus *Orthopyxis* had not been previously defined, Bale and Nutting are really substituting a new genus for *Eucopella*, although retaining all the characteristics of that genus, for although a name is given that had been used previously, they do not know and never can know that Agassiz had any such characteristics in mind when he applied the subgeneric name *Orthopyxis* to his species *poterium*.

Genus GONOTHYRÆA.

GONOTHYRÆA GRACILIS (Sars).

Laomedea gracilis SARS, Beretn. om zool. Reise, etc., 1851, p. 18.
Gonothyræa gracilis ALLMAN, Ann. and Mag. Nat. Hist., 1864, p. 374.
HINCKS, Br. Hyd. Zooph., 1868, p. 183.
FRASER, Hyd. Beaufort, 1912, p. 361.
FRASER, Hyd. Nova Scotia, 1913, p. 166.
NUTTING, Am. Hyd., iii, 1915, p. 70.

Distribution.—Canso, Barrington passage, low water (Fraser); off High Duck island, between Two and Three islands, off Swallowtail light, 30 to 40 fathoms off Bliss island, off St. Andrews point, off Joe's point, off Dochet island.

GONOTHYRÆA LOVENI (Allman).

Laomedea loveni ALLMAN, Ann. and Mag. Nat. Hist., 1859, p. 138.
Gonothyræa loveni ALLMAN, Ann. and Mag. Nat. Hist., 1864, p. 374.
NUTTING, Hyd. Woods Hole, 1901, p. 352.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 166.
NUTTING, Am. Hyd., iii, 1915, p. 69.

Distribution.—St. Andrews, Gaspé, Malpeque, Seven islands (Stafford); Chedacbucto bay, 20 fathoms (Fraser); Nigger reef, off Joe's point, off Head Harbour island, Cumming's cove, 5 to 40 fathoms.

Stafford mentions a species of *Gonothyræa* which occurs at Malpeque, between the clustered stems of *Tubularia*: "Its hydrotheca has about 24 long, narrow, rigid, sharp teeth, separated by broad, rounded spaces below and continuing as thickened lines down the hydrotheca." It is unfortunate that he did not describe this species more fully and give figures of it, since, as far as I am aware, there has been no species of *Gonothyræa* described with hydrothecæ like these. *Gonothyræa gracilis* (Sars) has hydrothecæ with long, slender, sharp, teeth but each hydrotheca has only 10 to 12 of them. Twenty-four is an unusually large number of teeth to be found on the hydrothecal margin of any hydroid species. The thickened longitudinal lines have not been mentioned in connection with other species of this genus.

Genus OBELIA.

OBELIA ARTICULATA (A. Agassiz).

(Fig. 1.)

Eucope articulata A. Agassiz, N. A. Acalephæ, 1865, p. 89.

Trophosome.—Largest colonies reaching a height of 7 cm., most of them much less than this; stem usually simple, although in some of the large colonies there is a

slight indication of fasciculation; main stem continuous throughout and distinctly heavier than any of the branches; branches short and slender; main stem and branches with two to four annulations above the point where the branch or pedicel comes off; branches similarly annulated at their origin. Hydrothecate pedicels arising from each axil and one or two from each node, usually annulated throughout; hydrothecæ much deeper than wide; margin with 12 to 14 low, rounded teeth.

Gonosome.—Gonangia much elongated, with a distinct collar, borne on pedicels that are annulated throughout. They appear in the axils of the pedicels and smaller branches and at times are very numerous.

Distribution.—St. Croix river, reef near Biological station, off Joe's point, off St. Andrews point, St. Andrews island,, Chamcook harbour, Minister's island, Wolves island, off Swallowtail light, Grand Manan.

I have no doubt that this species which is common in the vicinity of the Biological station is the same as A. Agassiz described as *Eucope articulata* but his description is not very complete, hence I have included a full description at this time. The species resembles *Obelia dichotoma* in its mode of branching, *O. longissima* in the nature and arrangement of the hydrothecæ and O. *commissuralis* in the nature and arrangement of the gonangia. It is so much like these species in these respects that unless one gets a complete fertile colony it is somewhat difficult at times to be sure that it is not one of these species. It is quite possible that some of the records given for these other species should have been given for *O. articulata.*

OBELIA COMMISSURALIS McCrady.

Obelia commissuralis McCRADY, Gymno. Charleston har., 1857, p. 95.
NUTTING, Hyd. Woods Hole, 1901, p. 350.
HARGITT, Am. Nat., 1901, p. 382.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 23.
FRASER, Hyd. Nova Scotia, 1913, p. 167.
NUTTING, Am. Hyd., iii, 1915, p. 83.

Distribution.—Grand Manan (Verrill); Canso, low water (Fraser); Grand Manan (A. Agassiz); Seven islands.

OBELIA DICHOTOMA (Linnæus).

Sertularia dichotoma Linnæus, Syst. Nat., 1758, p. 812.

Obelia dichotoma HINCKS, Br. Hyd. Zooph., 1868, p. 156.
NUTTING, Hyd. Woods Hole, 1901, p. 350.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 23.

Obelia pyriformis WHITEAVES, Mar. Invert. East. Can., 1901, p. 23.

Obelia dichotoma STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 167.
NUTTING, Am. Hyd., iii, 1915, p. 80.

Distribution.—Nova Scotia, Métis (Dawson); St. Andrews, Gaspé, Seven islands (Stafford); Canso, low water (Fraser); Grand Manan (A. Agassiz); Joe's point, east of Spruce island 17 fathoms, Brier island, 33 to 39 fathoms.

OBELIA FLABELLATA (Hincks).

Campanularia flabellata HINCKS, Ann. and Mag. Nat. Hist., 1866, p. 297.

Obelia flabellata HINCKS, Br. Hyd. Zooph., 1868, p. 157.
NUTTING, Hyd. Woods Hole, 1901, p. 350.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
NUTTING, Am. Hyd. iii, 1915, p. 84.

Distribution.—St. Andrews, Seven islands (Stafford); between White and Spruce islands.

OBELIA GENICULATA (Linnæus).

Sertularia geniculata LINNÆUS, Syst. Nat., 1767, p. 1312.

Obelia geniculata HINCKS, Br. Hyd. Zooph., 1868, p. 149.
NUTTING, Hyd. Woods Hole, 1901, p. 350.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 23.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 167.
FRASER, Grampus Hydroids, 1915, p. 73.
NUTTING, Am. Hyd., iii, 1915, p. 73.

Distribution.—Bay of Fundy and northward, low water to 40 fathoms (Verrill); gulf of St. Lawrence (Dawson); St. Andrews, Gaspé, Seven islands (Stafford); Barrington passage, 3 fathoms, Canso, low water (Fraser); High Duck island, Horse island, Whale cove, off Swallowtail light, Wolves, north of Green island, Bliss island, Deer island, off Joe's point, St. Andrews.

OBELIA HYALINA Clarke.

Obelia hyalina CLARKE, Bull. Mus. Comp. Zool., 1879, p. 241.
FRASER, Hyd. Beaufort, 1912, p. 363.
NUTTING, Am. Hyd., iii, 1915, p. 76.

Distribution.—On sargassum in the gulf stream, east of Nova Scotia.

OBELIA LONGISSIMA (Pallas).

Sertularia longissima PALLAS, Elench. Zooph., 1766, p. 119.

Obelia longissima HINCKS, Br. Hyd. Zooph., 1868, p. 154.
NUTTING, Hyd. Woods Hole, 1901, p. 351.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 23.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
NUTTING, Am. Hyd., iii, 1915, p. 85.

Distribution.—Bay of Fundy (Verrill); St. Andrews, Seven islands (Stafford); off Bliss island, Indian Head bay, off Joe's point, St. Andrews.

Family *CAMPANULINIDÆ*.

Genus CALYCELLA.

CALYCELLA SYRINGA (Linnæus).

Sertularia syringa LINNÆUS, Syst. Nat., 1767, p. 1311.

Campanularia syringa STIMPSON, Mar. Invert. Grand Manan, 1854, p. 8.

Calycella syringa HINCKS, Br. Hyd. Zooph., 1868, p. 206.
NUTTING, Hyd. Woods Hole, 1901, p. 355.
WHITEAVES, Mar. Invert. East. Can., 1901, p. 23.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 168.
FRASER, Hyd. V. I. region, 1914, p. 156.

Distribution.—Off Duck island, 25 fathoms (Stimpson); Le Have bank, 45 fathoms (Smith and Harger); gulf of St. Lawrence, on the Orphan bank and about half-way between East cape, Anticosti, and the Bird rocks, in 313 fathoms (Whiteaves); St. Andrews, Malapeque, Gaspé, Seven islands (Stafford); Barrington passage, shallow water, Canso banks, 50 fathoms (Fraser); at almost all points where collecting was done in the bay of Fundy.

In my 1914 paper reasons are given for believing that *Calycella pygmæa* is not distinct from *Calycella syringa*

Genus CUSPIDELLA.

Cuspidella costata Hincks.

Cuspidella costata Hincks, Br. Hyd. Zooph., 1868, p. 210.
Stafford, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Gaspé (Stafford).

Cuspidella grandis Hincks.

Cuspidella grandis Hincks, Br. Hyd. Zooph., 1868, p. 210.
Whiteaves, Mar. Invert. East. Can., 1901, p. 24.

Distribution.—Orphan bank (Whiteaves); Coteau harbour, Long island, Labrador (Packard).

Genus *OPERCULARELLA*.

Opercularella lacerata (Johnston).

Campanularia lacerata Johnston, Br. Zooph., 1847, p. 120.

Opercularella lacerata Hincks, Br. Hyd. Zooph., 1868, p. 194.
Nutting, Hyd. Woods Hole, 1901, p. 354.
Stafford, Fauna Atlantic Coast, 1912, p. 73.
Fraser, Hyd. Nova Scotia, 1913, p. 168.

Distribution.—St. Andrews (Stafford); Fox island, Chedabucto bay, low tide (Fraser); Niger reef, weir stakes, St. Andrews island, Brier island, 33 to 39 fathoms.

Opercularella pumila Clark.

Opercularella pumila Clark, New England Hydroids, 1876, p. 61.
nana Hartlaub, Die Hydromedusen Helgolands, 1897, p. 502.
pumilla Hargitt, Hyd. Woods Hole, 1909, p. 375.

Distribution.—Weir stakes, St. Andrews island.

The description and figures given by Hartlaub for *Opercularella nana* agree perfectly with the creeping form of *Opercularella pumila* as described by Clark. Clark found but empty gonangia but Hartlaub found and described the complete gonosome. There is no question but that the species is distinct from *O. lacerata* (Johnston). In the specimens found in the Bay of Fundy, the hydrothecæ are only about half as long (·25) in *O. pumila* as they are in *O. lacerata* (·45 mm) and the gonangia are of an entirely different shape. In *O. lacerata* they are rounded or truncate at the distal end, while in *O. pumila* the distal portion is drawn out to become much more tubular.

All of the material obtained at St. Andrews I. was of the creeping type but it was well supplied with gonangia.

Genus STEGOPOMA.

Stegopoma plicatile (Sars).

Lafœa plicatile Sars, Forhandl., 1863, p. 31.

Stegopoma plicatile Levinsen, Medusæ, Ctenophorer, etc., 1893, p. 36.
Broch, Coelentérés du Fond, 1912, p. 11.
Fraser, Hyd. V. I. region, 1914, p. 161.

Distribution.—Bay of Islands, Newfoundland.

Genus TETRAPOMA.

Tetrapoma quadridentatum (Hincks).

Calycella quadridentata Hincks, Ann. and Mag. Nat. Hist., 1874, p. 149.
Tetrapoma quadridentatum Levinsen, Medusar, Ctenophorer, etc., 1893, p. 180.
Calycella quadridentata Stafford, Fauna Atlantic Coast, 1912, p. 73.
Distribution.—Gaspé (Stafford).

Family *HALECIDÆ.*

Genus HALECIUM.

HALECIUM ARTICULOSUM Clark.

Halecium articulosum CLARK, New England Hyd., 1876, p. 63.
NUTTING, Hyd. Woods Hole, 1901, p. 358.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. V.I. region, 1914, p. 164.

Distribution.—St. Andrews (Stafford); Wolves, between White and Spruce islands, southwest of Deer island, off Sandreef light, 15 fathoms, off Harbour island, 25 fathoms, off Joe's point 10 fathoms, reef near Biological station.

HALECIUM BEANI (Johnston).

Thoa beani JOHNSTON, Br. Zooph., 1847, p. 120.

Halecium beani HINCKS, Br. Hyd. Zooph., 1868, p. 224.
NUTTING, Hyd. Woods Hole, 1901, p. 358.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 168.

Distribution.—St. Andrews, Seven Islands (Stafford); Barrington passage, 5f., Canso banks, 50f. (Fraser); at many points from the south end of Grand Manan to the head of Passamaquody bay.

HALECIUM CURVICAULE Lorenz.

Halecium curvicaule LORENZ, Polypomedusen von Jan Mayen, 1886, p. 3.
BROCH, Hyd. Arkt. Meere, 1909, p. 150.

Distribution.—Off Joe's point, off Deer island, off Brier island, 33-39f.

HALECIUM GRACILE Verrill.

Halecium gracile VERRILL, Invert. An. Vineyard sd., 1873, p. 729.
NUTTING, Hyd. Woods Hole, 1901, p. 358.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 24.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—St. Andrews, Seven islands (Stafford); reef near Biological Station St. Andrews, 5 to 10 fathoms.

HALECIUM HALECINUM (Linnæus).

Sertularia halecina LINNÆUS, Syst. Nat., 1767, p. 1308.

Halecium halecinum HINCKS, Br. Hyd. Zooph., 1868, p. 221.
NUTTING, Hyd. Woods Hole, 1901, p. 357.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 24.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Chateau bay, strait of Bell Isle, 30 fathoms, Bay of Funday (Packard); Bay of Fundy (Dawson); Bay of Fundy (Whiteaves); St. Andrews (Stafford); St. Andrews, off Deer island.

HALECIUM MINUTUM Broch.

Halecium minutum BROCH, Nordmeer gesammelten hydroiden, 1903, p. 4.
FRASER, Hyd. Nova Scotia, 1913, p. 168.

Distribution.—Canso banks, 50 fathoms (Fraser); Brier island, 22 fathoms, Bay of Islands, Newfoundland, 50 to 60 fathoms.

HALECIUM MURICATUM (Ellis and Solander).

Sertularia muricatum ELLIS AND SOLANDER, Nat. Hist. Zooph., 1786, p. 59.
Halecium muricatum HINCKS, Br. Hyd. Zooph., 1868, p. 223.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 25.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 169.

Distribution.—15 miles south southeast of Bonaventure island, 50 fathoms (Whiteaves); off Caribou island, 30 to 50 fathoms, Square island, Labrador (Packard); St. Andrews, Canso, Gaspé (Stafford); Canso banks, 50 fathoms (Fraser); Quoddy river, 23 to 47 fathoms, Head Harbour island, Deer island, between Big Duck and Cheyne island, off Spruce island, 11 to 35 fathoms, between Two and Three islands, off Brier island, 33 to 39 fathoms.

HALECIUM SESSILE Norman.

Halecium sessile NORMAN, Hyd. Hebrides, 1866, p. 196.
HINCKS, Br. Hyd. Zooph., 1868, p. 229.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 25.

Distribution.—Between East cape, Anticosti and Bird rocks, 12 fathoms (Whiteaves).

HALECIUM TENELLUM Hincks.

Halecium tenellum HINCKS, Ann. and Mag. Nat. Hist., 1861, p. 252.
HINCKS, British Hyd. Zooph., 1868, p. 226.
NUTTING, Hyd. Woods Hole, 1901, p. 357.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 169.

Distribution.—St. Andrews, Gaspé, Seven islands (Stafford); Canso banks, 50 fathoms (Fraser); common from the north end of Campobello island to the head of Passamaquoddy bay, Brier island, Seven islands, bay of Islands, Newfoundland.

Family *HEBELLIDÆ*.

Genus HEBELLA.

HEBELLA CALCARATA (A. Agassiz).

Lafœa calcarata A. AGASSIZ, N. A. Acalephæ, 1865, p. 122.
HARGITT, Am. Nat., 1901, p. 387.
Hebella calcarata NUTTING, Hyd. Woods Hole, 1901, p. 353.
FRASER, Hyd. Beaufort, 1912, p. 371.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Canso (Stafford).

HEBELLA (?) *pocillum* Hincks.

Lafœa pocillum HINCKS, Br. Hyd. Zooph., 1868, p. 204.

Distribution.—St. Andrews.

There was no gonosome present on the St. Andrews specimens to settle the question definitely as to whether this species is a *Lafœa* or an *Hebella* but as there is a distinct diaphragm in the hydrotheca, it agrees with *Hebella* in that respect and is so placed.

Family *LAFŒIDÆ.*

Genus CRYPTOLARIA.

CRYPTOLARIA TRISERIALIS Fraser.

Cryptolaria triserialis FRASER, Hyd. Nova Scotia, 1913, p. 170.

Distribution.—Off Durell island, Chedabucto bay, 20 fathoms (Fraser).

Genus FILELLUM.

FILELLUM SERPENS (Hassall).

Campanularia serpens HASSALL, Trans. Micro. Soc., 1852, p. 163.
Filellum serpens HINCKS, Br. Hyd. Zooph., 1868, p. 214.
Reticularia serpens VERRILL, Check-list, 1879, p. 79.
Filellum serpens FRASER, Beaufort Hydroids, 1912, p. 369.
FRASER, Hyd. Nova Scotia, 1913, p. 171.

Distribution.—Canso banks, 50 fathoms (Fraser); common from the north end of Campobello island to the head of Passamaquoddy bay and up the mouth of the St. Croix river, Brier island, 22 fathoms.

Genus GRAMMARIA.

GRAMMARIA ABIETINA (Sars).

Campanularia abietina SARS, Nyt. Mag. for Naturv., 1851, p. 139.
Grammaria robusta STIMPSON, Mar. Invert. Grand Manan, 1854, p. 9.
Grammaria abietina SARS, Norske Hydroider, 1863, p. 34.
Salacia abietina, HINCKS, Br. Hyd. Zooph., 1868, p. 212.
Lafœa abietina BONNEVIE, Norske, Nordhavs-Ex., 1899, p. 64.
Grammaria abietina WHITEAVES, Mar. Invert. E. Can., 1901, p. 28.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 171.
FRASER, Hyd. V. I. region, 1914, p. 173.

Distribution.—Grand Manan (Stimpson); Le Have bank, 60 fathoms (Smith and Harger); gulf of St. Lawrence, Trinity bay, 25 fathoms, and elsewhere (Whiteaves); Gaspé, Seven islands (Stafford); Chedabucto bay, 20 fathoms (Fraser); bay of Islands, Newfoundland, 50 to 60 fathoms.

GRAMMARIA GRACILIS Stimpson.

Grammaria gracilis STIMPSON, Mar. Invert. Grand Manan, 1854, p. 9.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 28.

Distribution.—Grand Manan (Stimpson).

Genus LAFŒA.

LAFŒA DUMOSA (Fleming).

Sertularia dumosa FLEMING, Edin. Phil. Jour., 1828, p. 83.
Lafœa dumosa HINCKS, Br. Hyd. Zooph., 1868, p. 200.
NUTTING, Hyd. Woods Hole, 1901, p. 355.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 24.

Lafœa robusta WHITEAVES, Mar. Invert. E. Can., 1901, p. 24.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Lafœa dumosa FRASER, Hyd. Nova Scotia, 1913, p. 171.
FRASER, Hyd. V. I. Region, 1914, p. 174.

Distribution.—Nova Scotia (Agassiz); between Anticosti and Gaspé, 120 to 200 fathoms (Whiteaves); St. Andrews, Gaspé, Seven islands (Stafford); Chedabucto bay, 20 fathoms (Fraser); common in all the Passamaquoddy bay area, Brier island, 22 fathoms.

LAFŒA FRUTICOSA Sars.

Lafœa fruticosa SARS, Norske Hydroider, 1863, p. 30.
HINCKS, Br. Hyd. Zooph., 1868, p. 202.
BONNEVIE, Norske Nordhavs-Ex., 1899, p. 64.
VERRILL, Check-list, 1879, p. 17.
STAFFORD, Fauna Atlantic Coast, 1912, p. 172.
FRASER, Hyd. Nova Scotia, 1913, p. 172.

Distribution.—Seven islands (Stafford); Chedabucto bay, 20 fathoms (Fraser); Chamcook harbour, 5 fathoms.

LAFŒA GRACILLIMA (Alder).

Campanularia gracillima ALDER, Trans. Tynes Nat. F. C., 1857, p. 39.

Lafœa gracillima BONNEVIE, Norske Nordhavs-Ex., 1899, p. 64.
NUTTING, Hyd. Woods Hole, 1901, p. 356.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 24.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 172.
FRASER, Hyd. V. I. region, 1914, p. 175.

Distribution.—Bay of Fundy (Verrill); Le Have bank, 45 to 60 fathoms (Smith and Harger); Gaspé, Seven islands (Stafford); Canso banks, 50 fathoms (Fraser); Brier island, Seven islands, bay of Islands, Newfoundland, 50 to 60 fathoms.

LAFŒA PYGMÆA Hincks.

Lafœa pygmæa HINCKS, Br. Hyd. Zooph., 1868, p. 205.

Hebella pygmæa NUTTING, Hyd. Woods Hole, 1901, p. 353.
BROCH, Nordmeer ges. Hyd., 1903, p. 5.
FRASER, Hyd. Nova Scotia, 1913, p. 172.

Distribution.—Chedabucto bay, 25 fathoms (Fraser).

LAFŒA SYMMETRICA Bonnevie.

Lafœa symmetrica BONNEVIE, Norske Nordhavs-Ex, 1899, p. 64.
BILLARD, Ex. Sc. "Travailleur" et du "Talisman," 1907, p. 176.
FRASER, Hyd. Nova Scotia, 1913, p. 172.

Distribution.—Chedabucto bay, 25 fathoms (Fraser).

Family *SERTULARIDÆ*.

Genus ABIETINARIA.

ABIETINARIA ABIETINA (Linnæus).

Sertularia abietina LINNÆUS, Syst. Nat., 1758, p. 808.
HINCKS, Br. Hyd. Zooph., 1868, p. 266.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 25.

Sertularella abietina NUTTING, Hyd. Woods Hole, 1901, p. 361.
Abietinaria abietina NUTTING, Am. Hyd. ii, 1904, p. 114.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 173.

Distribution.—Off Nova Scotia, 51 fathoms (Allman); Mingan island, gulf of St. Lawrence and Labrador (Packard); gulf and river St. Lawrence (Dawson and Whiteaves); St. Andrews, Gaspé, Canso, Seven islands (Stafford); Canso banks, 50 fathoms (Fraser); St. George's bank, Newfoundland (A. Agassiz); off Swallowtail light, southwest of Deer island, Head harbour, McMaster island, off Joe's point, Seven islands.

ABIETINARIA FILICULA (Ellis and Solander.)

Sertularia filicula ELLIS AND SOLANDER, Nat. Hist. Zooph., 1786, p. 57.
STIMPSON, Mar. Invert. Grand Manan, 1854, p. 8.
HINCKS, Br. Hyd. Zooph., 1868, p. 264.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 25.
Abietinaria filicula NUTTING, Am. Hyd. ii, 1904, p. 123.

Distribution.—Grand Manan, 20 fathoms (Stimpson); Labrador (Packard).

NOTE.—Stafford reports specimens of an *Abietinaria* species from Seven Islands, Quebec, but as all the information he gives concerning it is that it "most resembles *A. gigantea* Clark," it is impossible to place it.

Genus DIPHASIA.

DIPHASIA FALLAX (Johnston.)

Sertularia fallax JOHNSTON, Br. Zooph., 1847, p. 73.
STIMPSON, Mar. Invert. Grand Manan, 1854, p. 8.
Diphasia fallax HINCKS, Br. Hyd. Zooph., 1868, p. 249.
NUTTING, Hyd. Woods Hole, 1901, p. 361.
HARGITT, Am. Nat., 1901, p. 391.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 26.
NUTTING, Am. Hyd. ii, 1904, p. 114.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 173.

Distribution.—Grand Manan (Stimpson); Bay of Fundy, 20 to 55 fathoms (Verrill); St. Andrews (Stafford); Barrington passage, 4 fathoms (Fraser); common throughout the Passamaquoddy bay area, Brier island, 22 fathoms.

DIAPHASIA ROSACEA (Linnæus).

Sertularia rosacea LINNÆUS, Syst. Nat., 1758, p. 807.
Diphasia rosacea HINCKS, Br. Hyd. Zooph., 1868, p. 245.
NUTTING, Hyd. Woods Hole, 1901, p. 361.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 26.
NUTTING, Am. Hyd., ii, 1904, p. 107.
STAFFORD, Fauna Atlantic Coast, 1912, p. 74.
FRASER, Hyd. Nova Scotia, 1913, p. 174.

Distribution.—Strait of Belle Isle, 50 fathoms (Packard); St. Andrews (Stafford); Barrington passage (Fraser); off Deer island, 15 fathoms, off Frost ledges, Quoddy river, between White and Spruce islands, between Two and Three islands, Brier island, 33 to 39 fathoms.

DIPHASIA TAMARISCA (Linnæus).

Sertularia tamarisca LINNÆUS, Syst. Nat., 1758, p. 808.
Sertularia producta STIMPSON, Mar. Invert. Grand Manan, 1854, p. 8.
Diphasia tamarisca HINCKS, Br. Hyd. Zooph., 1868, p. 273.
Sertularia producta WHITEAVES, Mar. Invert. E. Can., 1901, p. 27.
Diphasia tamarisca NUTTING, Am. Hyd., ii, 1904, p. 108.

Distribution.—Grand Manan (Stimpson); Sea coal bay, N.S. (Verrill).

Nutting, apparently with good reason, has concluded that *Sertularia producta* Stimpson is synonymous with *Diphasia tamarisca* (Linnæus) and hence it is included here under that name.

Genus HYDRALLMANIA.

HYDRALLMANIA FALCATA (Linnæus).

Sertularia falcata LINNÆUS, Syst. Nat., 1758, p. 810.
Plumularia falcata STIMPSON, Mar. Invert. Grand Manan, 1854, p. 8.
Hydrallmania falcata HINCKS, Br. Hyd. Zooph., 1868, p. 273.
NUTTING, Hyd. Woods Hole, 1901, p. 364.
HARGITT, Am. Nat., 1901, p. 392.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 27.
NUTTING, Am. Hyd., ii, 1904, p. 124.
STAFFORD, Fauna Atlantic Coast, 1912, p. 74.
FRASER, Hyd. Nova Scotia, 1913, p. 174.

Distribution.—Grand Manan, 25 to 35 fathoms (Stimpson); bay of Fundy, low water to 110 fathoms, Anticosti, Mingan islands (Verrill); Le Have bank, 60 fathoms, Chebucto head, Halifax harbour, 20 fathoms (Smith and Harger); Sable island, Gaspé, Métis (Dawson); gulf of St. Lawrence (Whiteaves); Grand Manan (A. Agassiz); St. Andrews, Gaspé, Seven islands (Stafford); Barrington passage (Fraser); one of the comonest species of large size in the collection.

Genus SELAGINOPSIS.

SELAGINOPSIS MIRABILIS (Verrill).

Diphasia mirabilis VERRILL, Amer. Jour. Sci. Arts, 1872, p. 9.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 26.
Selaginopsis mirabilis NUTTING, Am. Hyd., ii, 1904, p. 128.
STAFFORD, Fauna Atlantic Coast, 1912, p. 74.
FRASER, Hyd. Nova Scotia, 1913, p. 174.

Distribution.—Le Have bank, 60 fathoms (Smith and Harger); Gaspé, Seven islands (Stafford); Canso banks, 50 fathoms (Fraser).

Genus SERTULARELLA.

SERTULARELLA CONICA Allman.

Sertularella conica ALLMAN, Hyd. Gulf Stream, 1877, p. 21.
NUTTING, Am. Hyd., ii, 1904, p. 79.
FRASER, Hyd. Nova Scotia, 1913, p. 174.

Distribution.—Canso banks, 50 fathoms (Fraser).

SERTULARELLA FUSIFORMIS (Hincks).

Sertularia fusiformis HINCKS, Ann. and Mag. Nat. Hist., 1861, p. 253.
HINCKS, Br. Hyd. Zooph., 1868, p. 243.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 26.

Sertularella fusiformis NUTTING, Am. Hyd., ii, 1904, p. 89.

Distribution.—Gulf of St. Lawrence, between Anticosti and Gaspé, 200 fathoms (Whiteaves).

SERTULARELLA POLYZONIAS (Linnæus).

Sertularia polyzonias LINNÆUS, Syst. Nat., 1758, p. 813.
STIMPSON, Mar. Invert. Grand Manan, 1854, p. 9.

Sertularella polyzonias HINCKS, Br. Hyd. Zooph., 1868, p. 235.
NUTTING, Hyd. Woods Hole, 1901, p. 362.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 25.
NUTTING, Am. Hyd., ii, 1904, p. 90.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 175.

Distribution.—Grand Manan, 10 to 40 fathoms (Stimpson); Le Have bank, 60 fathoms (Smith and Harger); Caribou island, (Packard); gulf of St. Lawrence (Whiteaves); St. Andrews, Gaspé,Seven islands (Stafford); Chedabucto bay, 10 to 20 fathoms (Fraser); common throughout the Passamaquoddy bay area, Seven islands.

SERTULARELLA RUGOSA (Linnæus).

Sertularia rugosa LINNÆUS, Syst. Nat., 1758, p. 809.
STIMPSON, Mar. Invert. Grand Manan, 1854, p. 9.

Sertularella rugosa HINCKS, Br. Hyd. Zooph., 1868, p. 259.

Sertularia rugosa WHITEAVES, Mar. Invert. E. Can., 1901, p. 25.

Sertularella rugosa NUTTING, Am. Hyd., ii, 1904, p. 82.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Grand Manan, deep water (Stimpson); Square island, Labrador, 30 fathoms (Packard); Seven islands (Stafford); High Duck island, between White and Spruce islands, Cumming's cove, West Quoddy head, Dochet island.

SERTULARELLA TRICUSPIDATA (Alder).

Sertularia tricuspidata ALDER, Ann. 'and Mag. Nat. Hist., 1856, p. 356.

Sertularella tricuspidata HINCKS, Br. Hyd. Zooph., 1868, p. 239.
NUTTING, Hyd. Woods Hole, 1901, p. 362.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 26.
NUTTING, Am. Hyd., ii, 1904, p. 71.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 175.

Distribution.—Bay of Fundy, 50 to 55 fathoms (Verrill); Le Have bank, 45 to 60 fathoms (Smith and Harger); gulf of St. Lawrence (Whiteaves); strait of Belle Isle, 40 fathoms (Packard); St. Andrews, Gaspé, Seven islands (Stafford); Canso banks, 50 fathoms (Fraser); very common everywhere in the Passamaquoddy bay area at all depths, Brier island, 33 to 39 fathoms.

Genus SERTULARIA.

SERTULARIA CORNICINA (McCrady).

Dynamena cornicina McCRADY, Gymno. Charleston Har., 1858, p. 204.
Sertularia cornicina NUTTING, Hyd. Woods Hole, 1901, p. 359.
NUTTING, Am. Hyd., ii, 1904, p. 58.
FRASER, Hyd. Beaufort, 1912, p. 374.

Distribution.—On sargassum in the Gulf Stream, east of Nova Scotia.

SERTULARIA PUMILA Linnaeus.

Sertularia pumila LINNÆUS, Syst. Nat., 1758, p. 807.
HINCKS, Br. Hyd. Zooph., 1868, p. 260.
NUTTING, Hyd. Woods Hole, 1901, p. 359.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 25.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 175.

Distribution.—Nova Scotia and Métis (Dawson); strait of Belle Isle, between tides (Packard); St. Andrews, Canso, Seven islands (Stafford); Canso, low water (Fraser); Grand Manan (A. Agassiz); High Duck island, Wolves, Indian Head bar, Souris, P.E.I., York harbour, bay of Islands, Newfoundland, Seven islands.

Genus THUIARIA.

THUIARIA ARGENTEA (Linnæus).

Sertularia argentea LINNÆUS, Syst. Nat., 1758, p. 809.
STIMPSON, Mar. Invert. Grand Manan, 1854, p. 8.
HINCKS, Br. Hyd. Zooph., 1868, p. 268.
Thuiaria argentea NUTTING, Hyd. Woods Hole, 1901, p. 364.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 27.
NUTTING, Am. Hyd., ii, 1904, p. 71.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. Nova Scotia, 1913, p. 176.

Distribution.—Grand Manan, 4 to 6 fathoms (Stimpson); Bay of Fundy, Nova Scotia coast, gulf of St. Lawrence, low water to 110 fathoms (Verrill); Northumberland strait, gulf of St. Lawrence (Whiteaves); Gaspé bay (Dawson); Caribou island, 8 fathoms (Packard); St. Andrews, Gaspé (Stafford); Barrington passage, 5 fathoms, Canso banks, 50 fathoms (Fraser); off Deer island, off Grand Manan, bay of Islands, Newfoundland, 50 to 60 fathoms.

THUIARIA CUPRESSINA (Linnæus).

Sertularia cupressina LINNÆUS, Syst. Nat., 1758, p. 808.
HINCKS, Br. Hyd. Zooph., 1868, p. 270.
Thuiaria cupressina NUTTING, Hyd. Woods Hole, 1901, p. 363.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 27.
NUTTING, Am. Hyd., ii, 1904, p. 72.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Off Nova Scotia, 51 fathoms (Allman); Bay of Fundy, low water to 100 fathoms (Verrill); Northumberland strait, gulf of St. Lawrence (Whiteaves); Henley harbour, strait of Belle Isle, 7 fathoms (Packard); St. Andrews (Stafford); St. Croix river, off Joe's point, McMaster island, Quoddy river, off Deer island, Whale cove, 20 to 30 fathoms, Brier island, 33 to 39 fathoms.

THUIARIA FABRICII (Levinsen).

Sertularia fastigiata FABRICIUS, Fauna Grœnlandica, 1780, p. 458.

Sertularia fabricii LEVINSEN, Vid. Middel. Naturh. Foren., 1892, p. 48.

Thuiaria fabricii NUTTING, Am. Hyd., ii, p. 1904, p. 71.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Gaspé, Islands (Stafford); St. Andrews.

THUIRIA IMMERSA Nutting.

Thuiaria immersa NUTTING, Am. Hyd., ii, 1904, p. 66.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Seven islands (Stafford); St. Croix river, Grand Manan, between Mohawk and Adam island, 35 fathoms, between Green and Three islands, McMaster island, off Deer island, off Brier island, 22 fathoms.

THUIARIA LATIUSCULA (Stimpson).

Sertularia latiuscula STIMPSON, Mar. Invert. Grand Manan, 1854, p. 8.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 26.

Thuiaria latiuscula NUTTING, Am. Hyd., ii, 1904, p. 69.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Grand Manan (Stimpson); Gaspé, Seven islands (Stafford); St. Andrews.

THUIARIA LONCHITIS (Ellis and Solander).

Sertularia lonchitis ELLIS AND SOLANDER, Nat. Hist. Zooph., 1786, p. 42.

Thuiaria articulata WHITEAVES, Mar. Invert. E. Can., 1901, p. 27.

Thuiaria lonchits NUTTING, Am. Hyd., ii, 1904, p. 66.
FRASER, Hyd. Nova Scotia, 1913, p. 176.

Distribution.—Le Have bank, 45 fathoms (Smith and Harger); gulf of St. Lawrence (Whiteveaves); Canso banks, 50 fathoms (Fraser); St. Andrews.

THUIARIA ROBUSTA Clark.

Thuiaria robusta CLARK, Alaskan Hyd., 1876, p. 227.
NUTTING, Am. Hyd., ii, 1904, p. 64.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Gaspé, Seven islands (Stafford).

THUIARIA SIMILIS (Clark).

Sertularia similis CLARK, Alaskan Hyd., 1876, p. 219.

Thuiaria similis NUTTING, Am. Hyd., ii, 1904, p. 69.
FRASER, West Coast Hyd., 1911, p. 77.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.
FRASER, Hyd. V. I. region, 1914, p. 199.

Distribution.—Gaspé (Stafford); St. Croix river, Quoddy river, West Quoddy head, Head Harbour island, 25 fathoms, Whale cove, Brier island, 22 fathoms, Seven islands.

THUIARIA TENERA (Sars).

Sertularia tenera SARS, Bidrag til Kundskaben etc., 1873, p. 20.

Thuiaria tenera NUTTING, Am. Hyd., ii, 1904, p. 70.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Gaspé, Seven islands (Stafford); St. Andrews, Brier island.

THUIARIA THUJA (Linnæus).

Sertularia thuja LINNÆUS, Syst. Nat., 1758, p. 809.

Thuiaria thuja HINCKS, Br. Hyd. Zooph., 1868, p. 275.
NUTTING, Hyd. Woods Hole, 1901, p. 364.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 26.
NUTTING, Am. Hyd., ii, 1904, p. 62.
STAFFORD, Fauna Atlantic Coast, 1912, p. 73.

Distribution.—Mingan islands (Packard); gulf of St. Lawrence (Whiteaves); Seven islands (Stafford); McMaster island, 30 fathoms.

NOTE.—Stafford refers to four species of *Thuiaria* from Gaspé, none of which he describes sufficiently to place, but apparently one of them is a *Synthecium* and is probably new and the others may be also.

Family *PLUMULARIDÆ*.

Genus AGLAOPHENOPSIS.

AGLAOPHENOPSIS CORNUTA (Verrill).

Cladocarpus cornutus VERRILL, Am. Jour. Sci. Arts, 1879, p. 310.

Aglaophenopsis cornuta NUTTING, Am. Hyd., i, 1900, p. 120.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 28.

Distribution.—Off Sable island, on Banquereau, 200 fathoms (Verrill).

Genus ANTENNULARIA.

ANTENNULARIA AMERICANA Nutting.

Antennularia americana NUTTING, Am. Hyd., i, 1900, p. 69.
NUTTING, Hyd. Woods Hole, 1901, p. 368.

Distribution.—St. Andrews.

ANTENNULARIA ANTENNINA (Linnæus).

Sertularia antennina LINNÆUS, Syst. Nat., 1767, p. 1310.

Antennularia antennina HINCKS, Br. Hyd. Zooph., 1868, p. 280.
NUTTING, Am. Hyd., 1900, p. 69.
NUTTING, Hyd. Woods Hole, 1901, p. 367.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 28.
STAFFORD, Fauna Atlantic Coast, 1912, p. 74.

Distribution.—Bay of Fundy, 10 to 60 fathoms (Verrill); St. Andrews (Stafford); channel off White Horse island.

Genus CLADOCARPUS.

CLADOCARPUS POURTALESI, Verrill.

Cladocarpus pourtalesi VERRILL, Am. Jour. Sci. Arts, 1879, p. 309.
NUTTING, Am. Hyd., i, 1900, p. 116.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 28.

Distribution.—Southwest of cape Sable, 112 to 115 fathoms, Banquereau, off Sable sland, 300 fathoms (Verrill).

CLADOCARPUS SPECIOSUS Verrill.

Cladocarpus speciosus VERRILL, Amer. Jour. Sci. Arts., 1879, p. 311.
NUTTING, Am. Hyd., i, 1900, p. 116.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 28.

Distribution.—Banquereau, off Sable island, 200 fathoms (Verrill).

Genus PLUMULARIA.

PLUMULARIA SETACEOIDES Bale.

Plumularia setaceoides BALE, Hyd. S. Australia, 1881, p. 28.
FRASER, Hyd. Beaufort, 1912, p. 382.

Distribution.—On sargassum, Gulf Stream, east of Nova Scotia.

Genus SCHIZOTRICHA.

SCHIZOTRICHA GRACILLIMA (Sars).

Plumularia gracillima SARS, Vid. Selsk. Forh., 1873, p. 86.

Plumularia verrilli CLARK, Trans. Conn. Acad. Sci., 1876, p. 64.
VERRILL, Prelim. Check-list, 1879, p. 18.

Schizotricha gracillima NUTTING, Am. Hyd., i, 1900, p. 80.
NUTTING, Hyd. Woods Hole, 1901, p. 366.
STAFFORD, Fauna Atlantic Coast, 1912, p. 74.

Distribution.—Grand Manan (Stafford).

Genus THECOCARPUS.

THECOCARPUS MYRIOPHYLLUM (Linnæus).

Sertularia myriophyllum LINNÆUS, Syst. Nat., 1767, p. 1309.

Aglaophenia myriophyllum HINCKS, Br. Hyd. Zooph., 1868, p. 290.

Thecocarpus myriophyllum NUTTING, Am. Hyd., i, 1900, p. 107.
WHITEAVES, Mar. Invert. E. Can., 1901, p. 28.

Distribution.—Le Have bank, 60 fathoms (Smith and Harger); off cape Gaspé, 60 fathoms (Whiteaves); Mingan islands (A. Agassiz).

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EXPLANATION OF FIGURES.

(All drawings except 1*a* and 2*a* magnified 25 diameters.)

PLATE I.

1. *Obelia articulata.*
   - *a.* Colony, natural size.
   - *b.* Portion of colony to show nature and arrangement of hydrothecæ and gonangia.
2. *Bimeria brevis.*
   - *a.* Colonies, natural size.
   - *b.* Branched colony.
   - *c.* Unbranched individuals.

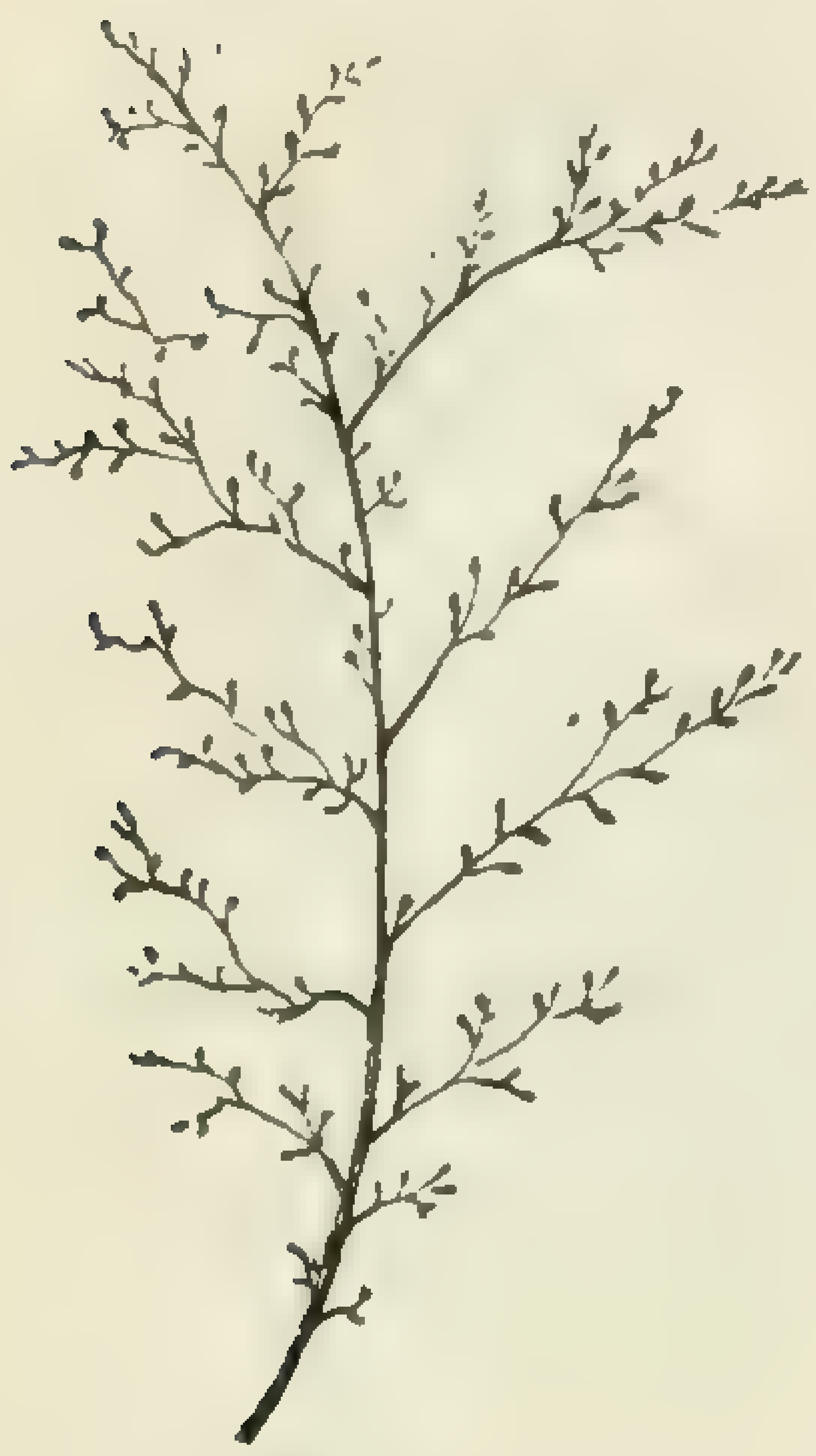
PLATE II.

3. *Clytia johnstoni,* hydrothecæ.
   - *a.* From the Devon Coast.
   - *b.* From St. Mary's bay, N.S.
   - *c.* From the coast of Grand Manan.
   - *d.* From Bliss island.
   - *e.* From Deer island.
   - *f.* From the St. Croix river.

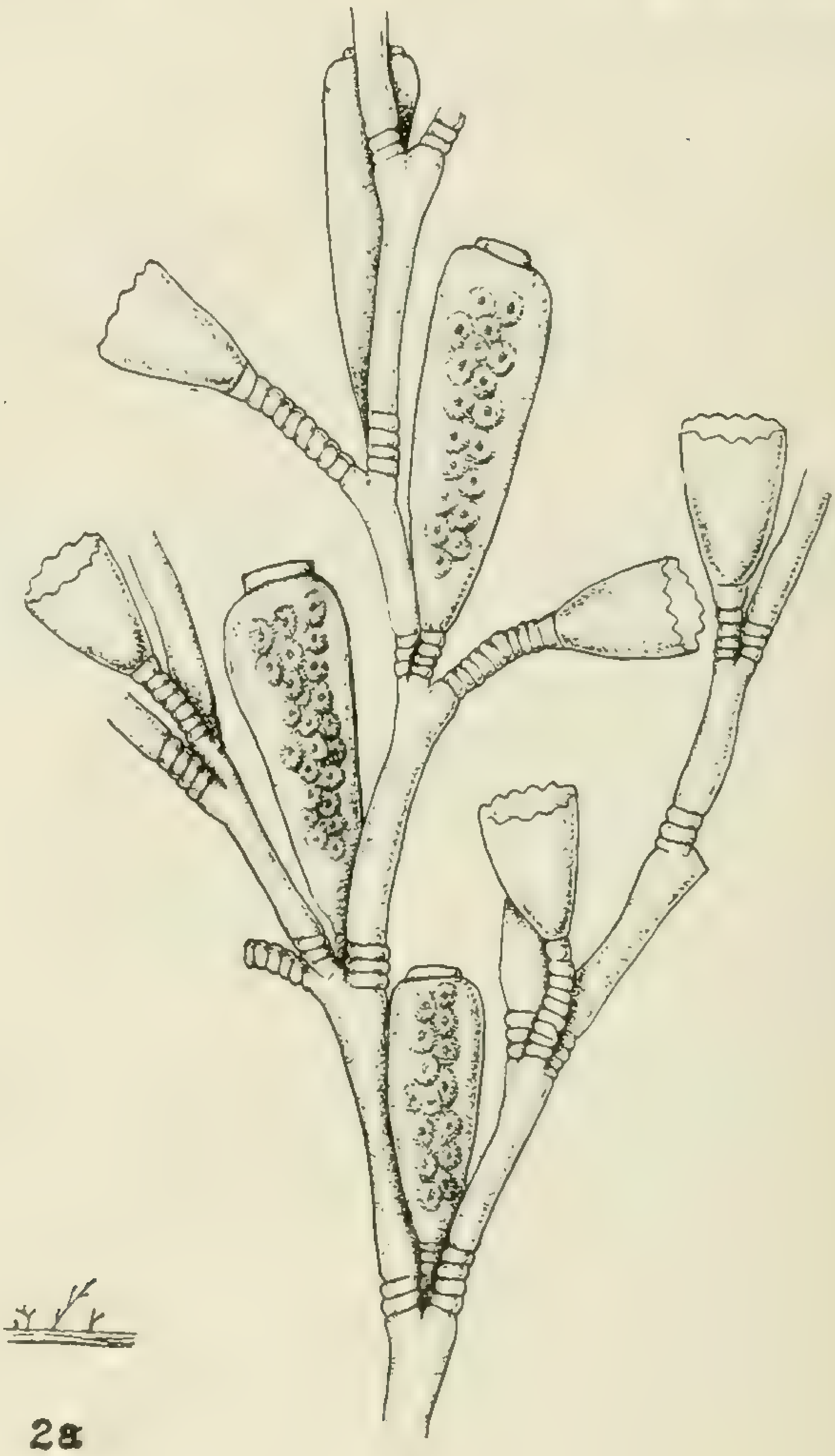
Drawings by Clara A. Fraser.

PLATE I

HYDROIDS OF EASTERN CANADA. C. McLean Fraser.

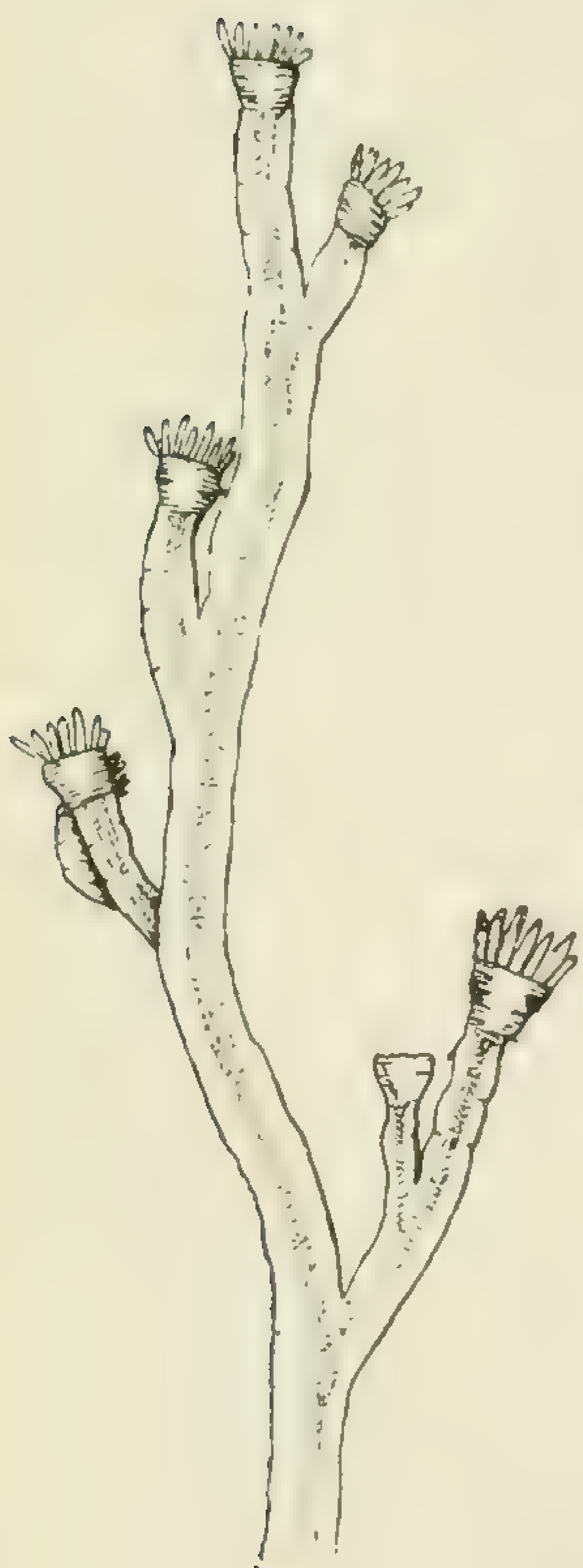


1a

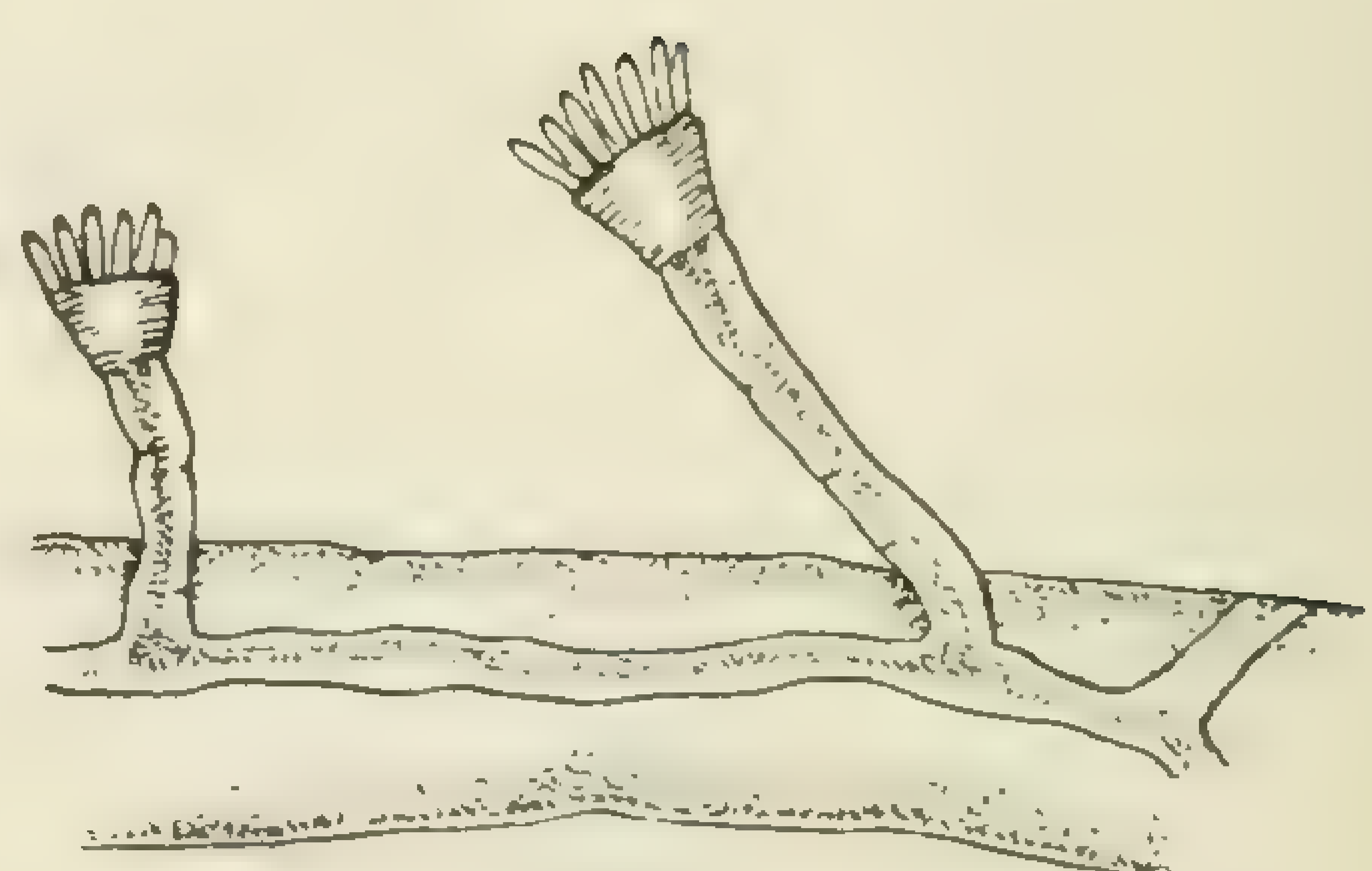


1b

2a



2b



2c

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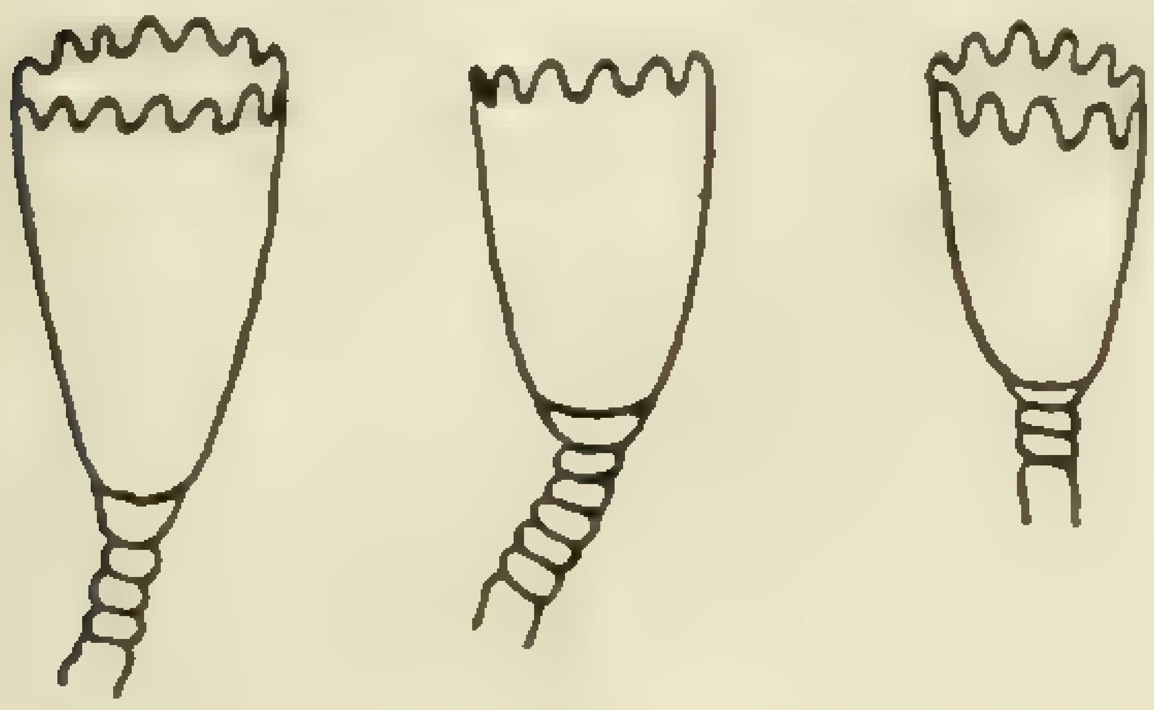
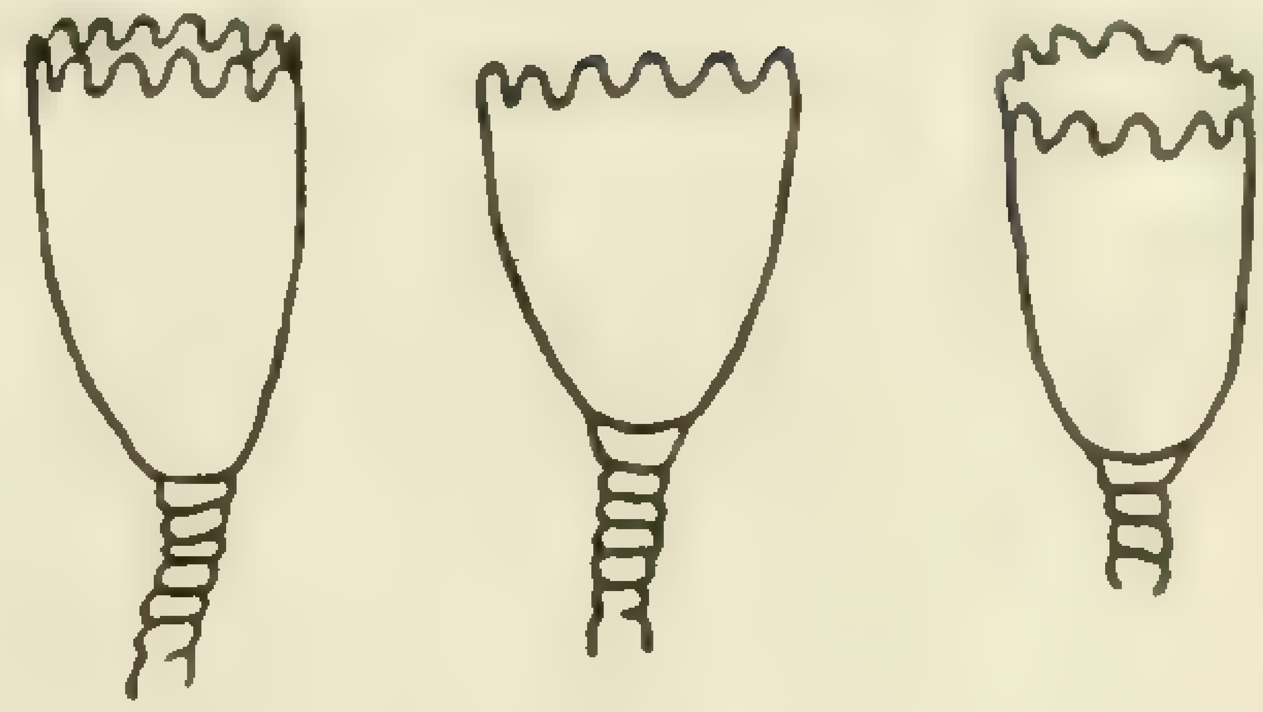
PLATE II



3a



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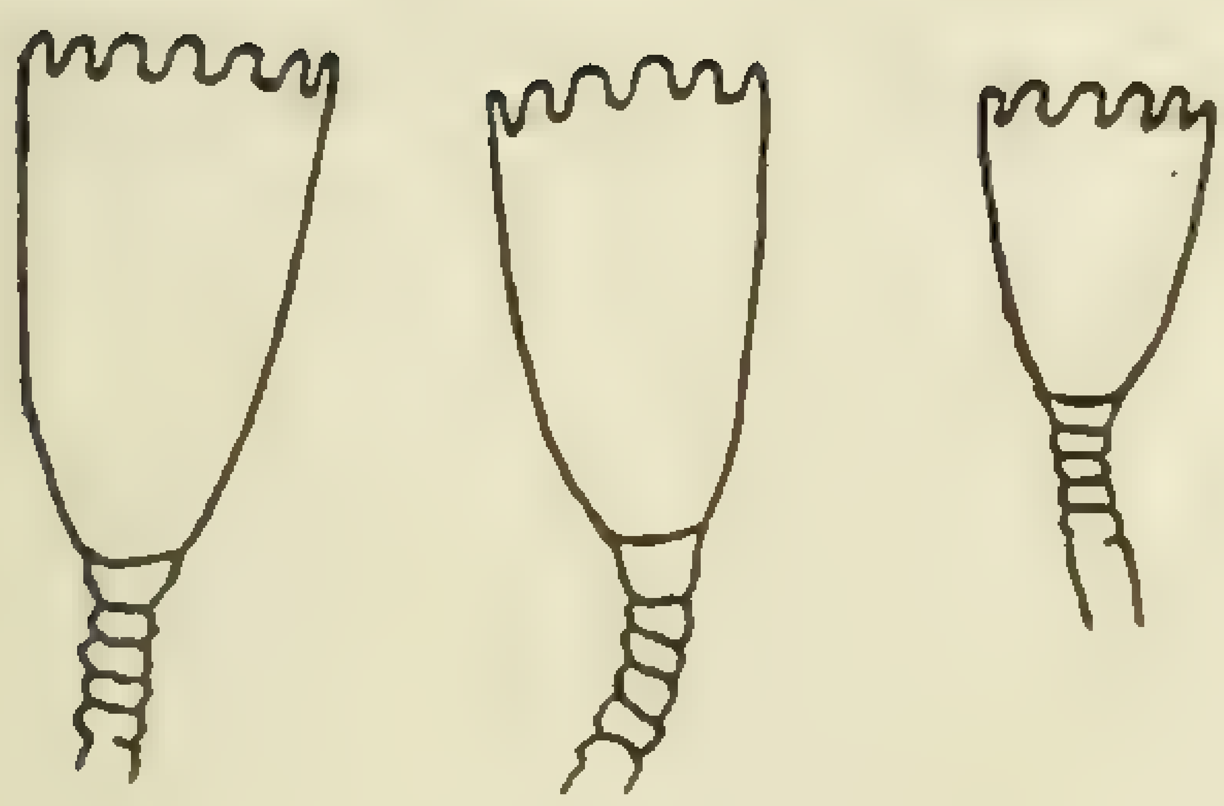

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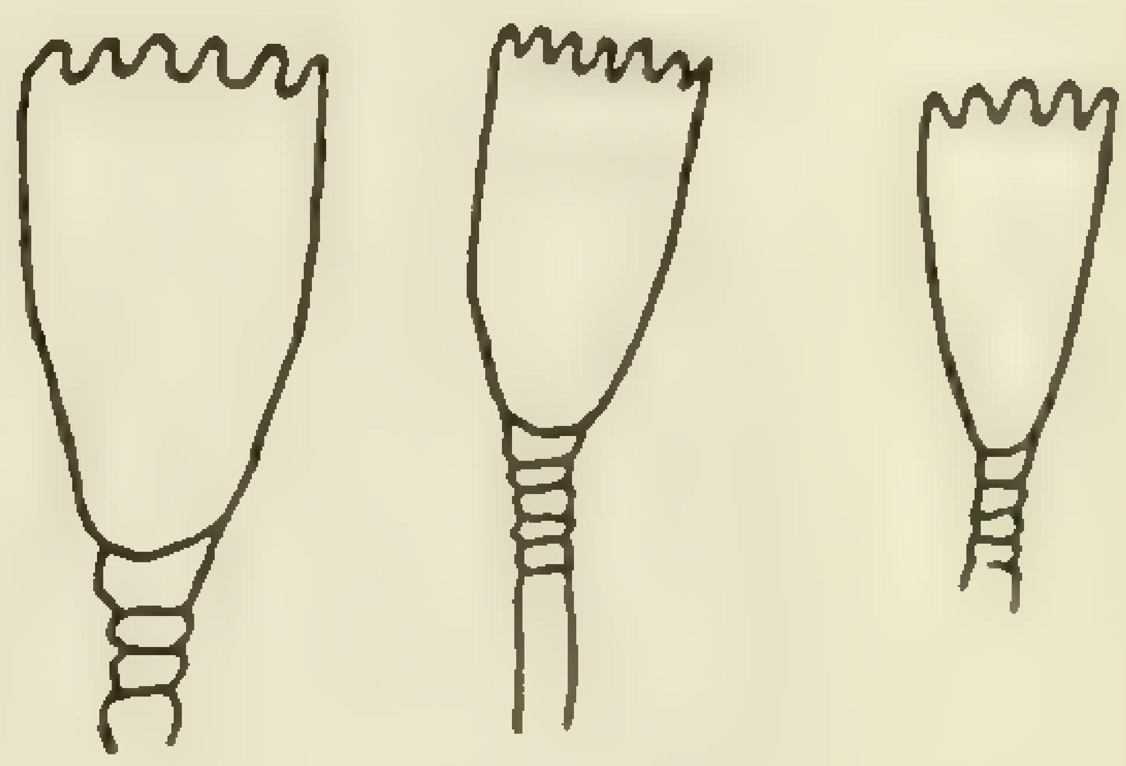

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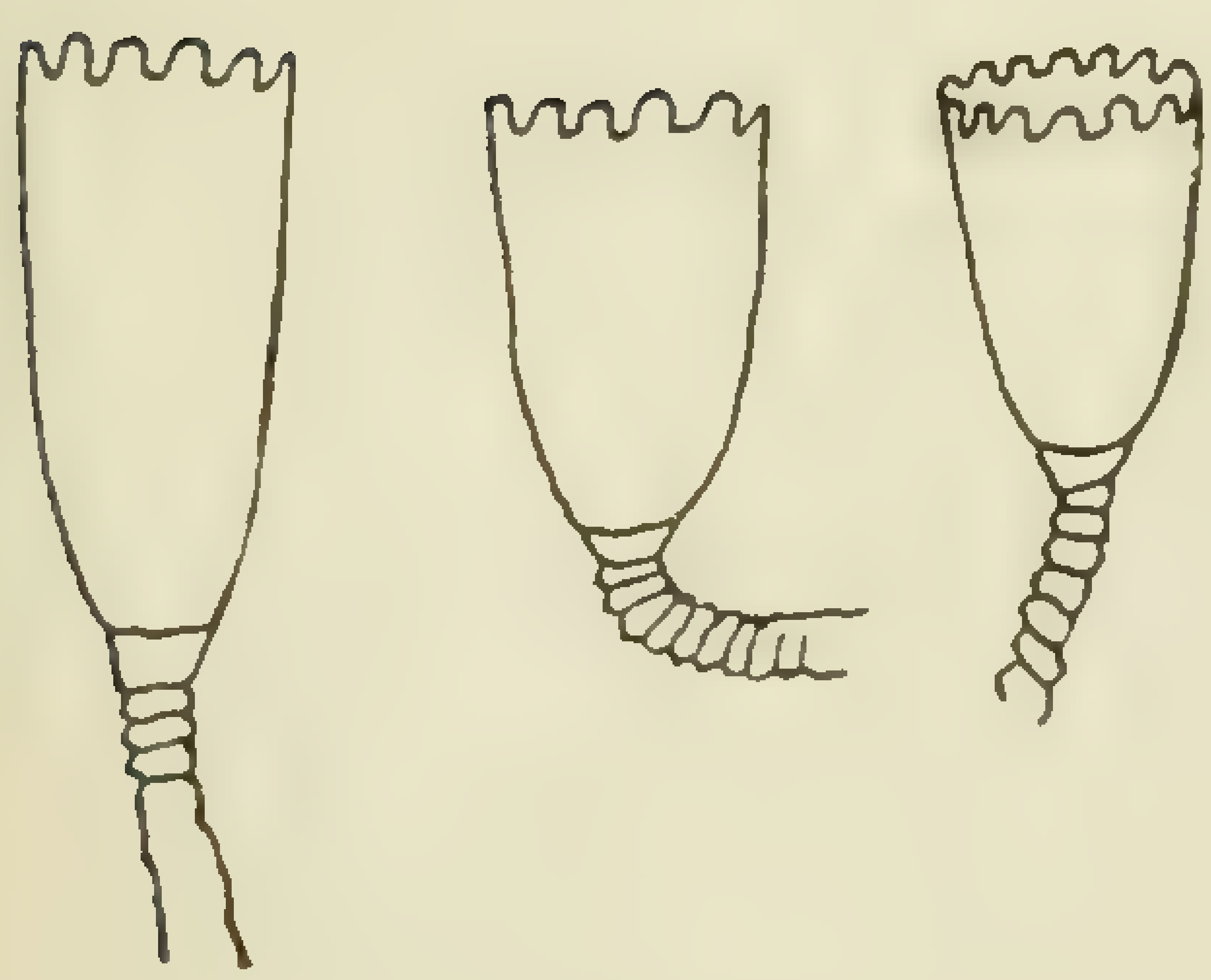
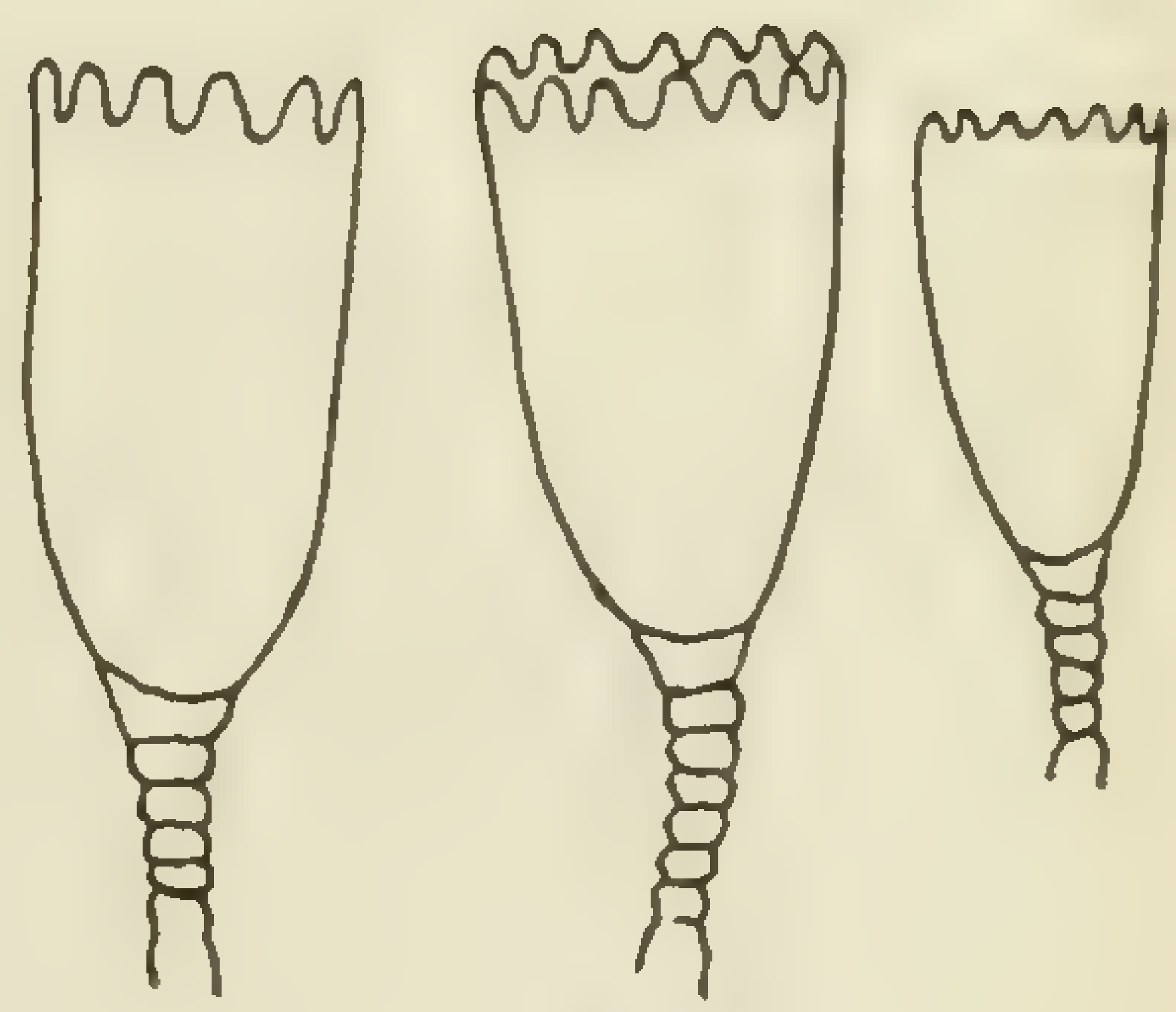


3e



3f

Clara A. Fraser, del.